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Technical Report

Rough Seas Transfer Ship

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Heavy lift ships are used to transport large marine equipment such as oil platforms and naval vessels. The major limitation for current heavy lift ships in naval operation is that they can only offload cargo in calm sea conditions. For the United States Navy, a dedicated lift ship capable of operating in moderate seas is required. The Rough Seas Transfer Ship (RSTS) will carry four light density amphibious connectors such as the Landing Craft, Air Cushioned (LCAC) at a fleet speed of 20 knots. The RSTS will also conduct joint operations with Military Sealift Command ships and be capable of ballasting to unload its cargo up to sea state 5 and de-ballasting for transit. Currently there is no craft that can meet these stringent US Navy operational requirements. This innovation cell is proposing a trimaran heavy lift ship in order to utilize the seakeeping characteristics of the trimaran hull while providing the deck area of a traditional heavy lift ship. The ship will ballast down and trim to the stern to place the stern of the working deck under the water surface to allow loading/off-loading of LCACs.

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Abstract

Heavy lift ships are used to transport large marine equipment such as oil platforms and naval vessels. The major limitation for current heavy lift ships in naval operation is that they can only offload cargo in calm sea conditions. For the United States Navy, a dedicated lift ship capable of operating in moderate seas is required.

The Rough Seas Transfer Ship (RSTS) will carry four light density amphibious connectors such as the Landing Craft, Air Cushioned (LCAC) at a fleet speed of 20 knots. The RSTS will also conduct joint operations with Military Sealift Command ships and be capable of ballasting to unload its cargo up to sea state 5 and de-ballasting for transit. Currently there is no craft that can meet these stringent US Navy operational requirements. This innovation cell is proposing a trimaran heavy lift ship in order to utilize the seakeeping characteristics of the trimaran hull while providing the deck area of a traditional heavy lift ship. The ship will ballast down and trim to the stern to place the stern of the working deck under the water surface to allow loading/off-loading of LCACs.

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At the Naval Surface Warfare Center Carderock Division, the single largest employer of summer interns is the Center for Innovation in Ship Design (CISD), which is part of the Ship Systems Integration and Design Department. The intern program is just one way in which CISD fulfils its role of conducting student outreach and developing ship designers.

The student team consisted of:

Andrew Nickerson

Charles Dorger

The team would also like to acknowledge the integral contribution that the following people made to this project. It is the accumulation of knowledge, experience, and mentorship of these people that allowed this project to reach its final state.

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Executive Summary

The United States Navy's Sea Base concept requires a vessel to transport military vehicles to the operational theater in conditions up to sea state 5. This vessel needs to combine the capabilities of a modern heavy lift ship with those of an amphibious assault ship to create a ship that can quickly transport and offload small craft such as the LCAC. A potential candidate to fulfill this requirement would be the Rough Seas Transfer Ship (RSTS).

The RSTS is an 11,400 mt displacement trimaran that can ballast and trim by the stern to allow LCACs to operate from the working deck. The ship has an overall length of 221 m, an overall breadth of 30 m, and a draft of 7 m which enables it to pass through the Panama Canal. A trimaran hullform was selected for its seakeeping characteristics, usable hull volume, and powering characteristics. The RSTS also has sheer applied on the aft end of the working deck to decrease the climbing angle for the LCAC. Land vehicle stowage is located on the working deck as well, to allow empty LCACs to be loaded with a compliment of military vehicles for transport to the operational theater.

Stability calculations were completed, for both for hydrostatics and during each stage of the ballasting operation, to validate the proposed design. It was found that the RSTS is stable through 70˚ of heel and throughout the ballasting operation.

The RSTS is not only limited to LCAC operations, but can also interface with Military Sealift Command (MSC) ships and small vessels within the Sea Base. Interfacing with MSC ships, such as the LMSR, can be accomplished through skin-to-skin transfers via the RSTS starboard crane, the LMSR onboard cranes, or the LMSR port ramp.

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Nomenclature

B	Beam
C_b	Block coefficient
CISD	Center for Innovation in Ship Design
C_p	Prismatic coefficient
C_w	Waterplane coefficient
KG	Keel to Center of Gravity
L	Length
LCAC	Landing Craft, Air Cushion
LMSR	Large, Medium Speed, Roll-on/Roll-off ship
MH	Main hull
MSC	Military Sealift Command
MTcm	Moment to trim 1 cm
OA	Overall
RSTS	Rough Seas Transfer Ship
SH	Side Hull
SUV	Sea Base Utility Vessel
T	Draft
TPC	Tonne per centimeter immersion
Δ	Ship Displacement in mt

1.0 Introduction

The United States Navy is developing the Sea Base concept, which will allow projection of land forces from up to 200 nautical miles offshore. This concept involves a collection of ships performing logistical operations at-sea, requiring a significant amount of connector ships to transport equipment from the Sea Base to the shore. Logistics operations must be performed in a variety of sea states in order for the Sea Base concept to be successful. Therefore, the Navy needs the ability to transfer and transport troops, vehicles, and other cargo in rough weather.

The Landing Craft, Air Cushioned (LCAC) is one of the primary movers of these cargos from sea to shore. However LCAC range limitations restrict operations to within 25 miles of land. There is a need for a connector ship that can provide an interface between Military Sealift Command (MSC) ships and LCACs to allow the transfer of cargo at sea and then transport the LCACs and their cargo into the operational theatre.

Currently, amphibious assault ships, such as the Whidbey Island class, are used to transport LCACs long distances. These large monohull ships have inadequate seakeeping for Sea Base transfer and transport operations in rough water. They also have a relatively large power requirement and provide capabilities that are unnecessary for that mission. Therefore, it can be concluded that the amphibious fleet ships are a larger, heavier, and more costly solution than a dedicated heavy-lift ship would be.

Commercial heavy-lift ships are considered a possibly cheaper and more specific solution to this need. It has been shown in experimental trials that these types of ships can act as a transfer platform with MSC ships because their large, flat working deck allows for a skin-to-skin ramp interface. However, heavy lift ships are focused on the slow speed, safe delivery of large mass and size cargos. The seakeeping and powering performances of these ships are extremely sea state limited. Sacrifices in seakeeping and speed are accepted to allow for greater cargo capacity. In this application, it is not acceptable to delay operations due to the sea state or to transit at slow speeds to the operational theater. Therefore, commercial heavy lift ships are not suitable to fulfill this role and a new ship design is needed.

2.0 Mission

The concept ship design is intended to meet the full list of given requirements as detailed in Annex A.

In essence, the design must be capable of fulfilling the role of a semi-submersible vessel for amphibious connectors, such as LCACs, or operating as a heavy lift ship.

The ship must also provide excellent seakeeping characteristics in both ballasted and unballasted modes and good powering performance at fleet operational speeds.

The other key requirements are that the ship must be capable of ballasting to load/offload fully loaded LCACs and perform other operations in sea state 5.

The design must have the capacity to carry 4 LCACs and 500 mt of land vehicles, have trans-oceanic range, and a 20 knot cruising speed.

3.0 Design Methodology & Summary

The starting point for this ship design was to identify hull form geometry and structural arrangements to allow good seakeeping (notably heave, roll, and pitch) in both operational modes without compromising propulsive performance or loading capabilities.

3.1 Hull Selection

Potential hull forms were analyzed so that the selected hull form would be able to successfully meet the design requirements for seakeeping, working deck area and size. The hull forms analyzed were the monohull, catamaran, SWATH (Small Waterplane Area Twin Hull), and trimaran. The analysis was based on general characteristics of the different hull forms.

Monohulls are often used in naval and heavy lift ship designs. They have relatively good seakeeping at low sea states, but quickly become limited at higher sea states. Modern LCAC carrying ships, such as the LSD-41, operate LCACs in conditions up to a sea state 3. Monohull ships with relatively small beams have good power requirements, but as the beam grows, so do the power requirements, and the seakeeping worsens. The monohull provides a large amount of volume to fulfill space requirements, but was not chosen. It was considered that the hullform that results from the load and ballasting requirements would likely possess poor resistance and seakeeping.

Some twin hulls, such as SWATHs, are known for improved seakeeping properties compared to monohull vessels. In addition, SWATH hulls generally are much more resistant to rolling effects, a major factor in seakeeping. A SWATH is a unique twin hull because the majority of the displaced volume is located below the waterline, which results in good immersion properties. However, both twin hull types have limited usable hull volume because it is divided between two smaller hulls. In addition, structural loads can be an issue because high wave induced loads can cause prying issues in the cross structure. Due to the symmetry of the twin hulls, placement of weights can also become a problem, due to the transverse separation between hull buoyancy and cargo loads. A twin hull form was not chosen because of the limited hull volume and the structural load issues.

Trimarans are vessels with three hulls: generally a large central hull and two smaller side hulls. They are generally very resistant to rolling, making them significantly more stable in higher sea states. Further, unlike catamaran or SWATH hullforms, the trimaran’s center hull has a large amount of usable interior hull volume for equipment, storage and ballast tanks. A large deck area can then be achieved while minimizing the separation between cargo loads and buoyancy forces on the hull, compared to a twin hull design, since the trimaran’s main hull provides the majority of the buoyant force. The trimaran hullform was selected for its good seakeeping characteristics, usable hull volume, and ship structural characteristics.

3.2 Ship Sizing

Excel spreadsheets were used to estimate weight and space. The weights and volumes were estimated by representative scaling from existing ships. The weight summary can be found in Section 4.4 and the weight breakdown can be found in Annex E. The volume breakdown can be found in Annex F.

An excel spreadsheet was used for simple hydrostatic calculations to estimate the moment to trim 1 cm (MTcm) and tonnes per cm (TPC). These results can be found in Annex G.

3.3 Working Deck

A large working deck was selected for transportation of the LCACs. It was determined that the working deck should be approximately 3,900 m^2 to accommodate loading four LCACs longitudinally. The large deck would give adequate working space for LCAC operations, but would also allow the RSTS to conduct a wider variety of missions as discussed further in Section 3.6.

3.4 Deck Selection

The ship trims by the stern to load and offload LCACs. The LCAC can remain stationary on up to a 5° slope. This angle was selected as the maximum possible deck angle to ensure that the LCAC could safely reach a final location of the working deck.

Two concepts were developed for decreasing the climbing angle. The first concept consisted of applying constant sheer over the entire length of the deck so that the stern of the ship had a greater freeboard than the bow of the ship. The advantage of this idea was that it would offer a smaller slope for the LCAC. However, to make this effective, it would remove a large amount of necessary hull volume.

The second concept developed was to apply sheer only at the aft end of the working deck. The advantage of this approach was that it decreased the climbing slope for the LCACs at the aft end of the deck while maintaining a flat surface for the rest of the working deck. Despite the potentially more complicated construction, the aft end of the RSTS working deck has two levels of sheer. This design will minimize the amount of water required to ballast and trim the ship while simultaneously minimizing the deck angle at the stern.

The working deck was divided into sections of 28 m, so that one LCAC could be parked entirely on each section when the ship is de-ballasted. The aft most section has a 2° sheer applied to it, the next section forward has a 1° sheer applied to it, and the remaining 84 m of the working deck has no sheer (see Figure 1). By configuring the deck in this manner, the amount of ballast and trim were minimized. Applying this type of sheer to the deck, though, increased the freeboard which in turn increased the amount of ballast required to lower the aft portion of the working deck below the water. However, the benefit of reducing the climbing angle for the LCACs was greater than the disadvantage of increasing the required ballast weight. When the RSTS is fully ballasted and trimmed, the first 28 m of the aft working deck would be at 2° to the water surface, the next 28 m would be at 3°, and the rest of the deck would be at 4° to the surface of the water (See Figure 2).

3.5 LCAC Operations

The working deck contains foldable barriers that are 16 meters apart to guide the LCACs during loading and offloading and enhance lateral control. The barriers can be folded down into the deck recess to facilitate deck operations. When the barriers are being used, they are bolted to the deck. When the barriers are not being used, they are unbolted from their upright position, and bolted into their folded position.

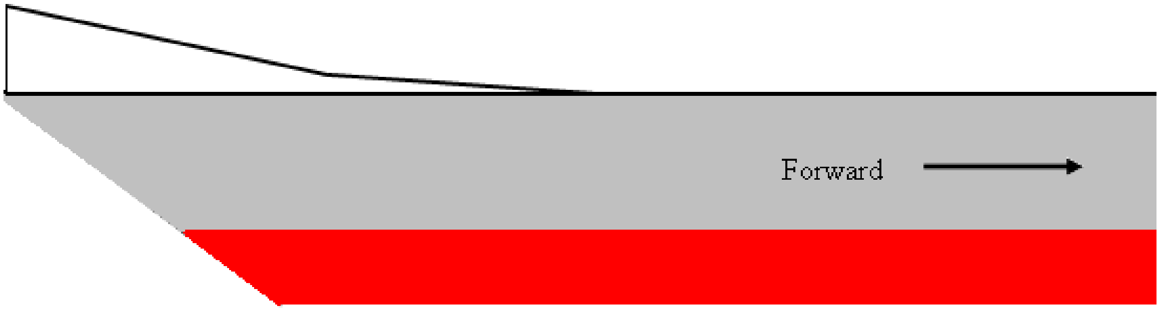

Figure 1: Exaggerated Starboard View of Stern Section

(Note: not to scale)

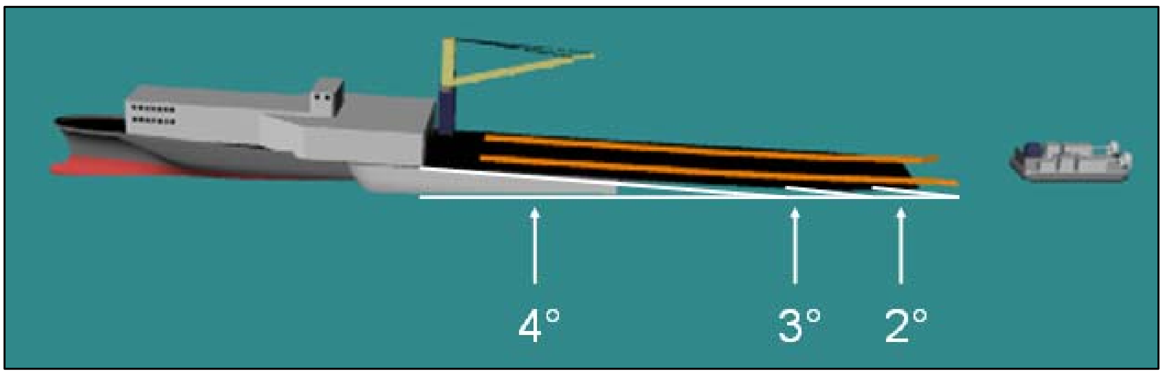

Figure 2: Fully Ballasted and Trimmed RSTS

The ship will load and offload LCACs by ballasting down by 1.5 meters and then trimming 4° by the stern. The ship must trim by the stern to lower the aft end of the working deck below the waterline allowing the LCACs to transition from the water to the working deck.

The LCAC loading concept is divided into four stages: Phase 0 to Phase 3. Table 1 lists and describes the LCAC loading/offloading phases while Figure 3 through Figure 6 displays each ballasting phase.

Phase	Description
0	Initial position
1	Ballast by 1.5 m draft
2	Trim 4° by the stern
3	Load/offload LCACs

Table 1: LCAC Loading Phases

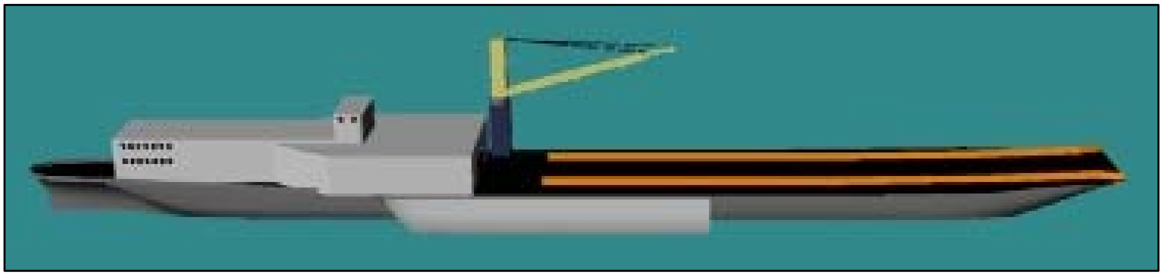

Figure 3: Phase 0 of LCAC Loading

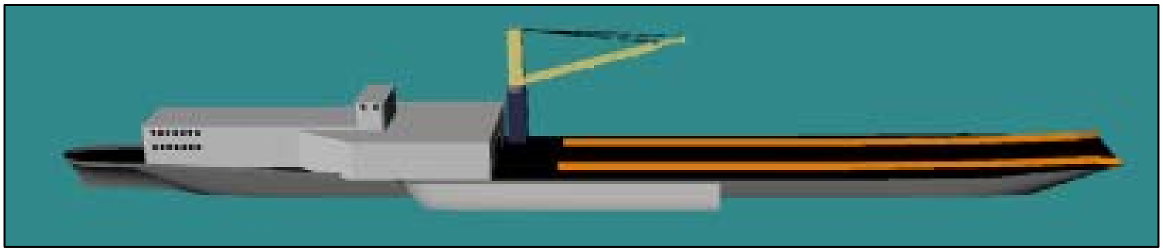

Figure 4: Phase 1 of LCAC Loading

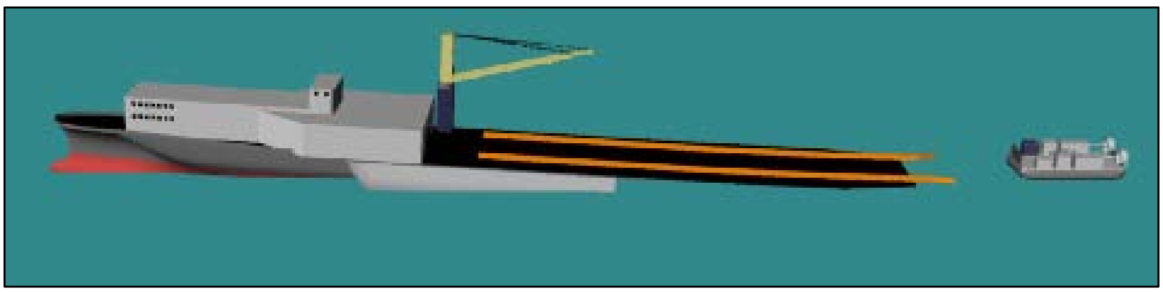

Figure 5: Phase 2 of LCAC Loading

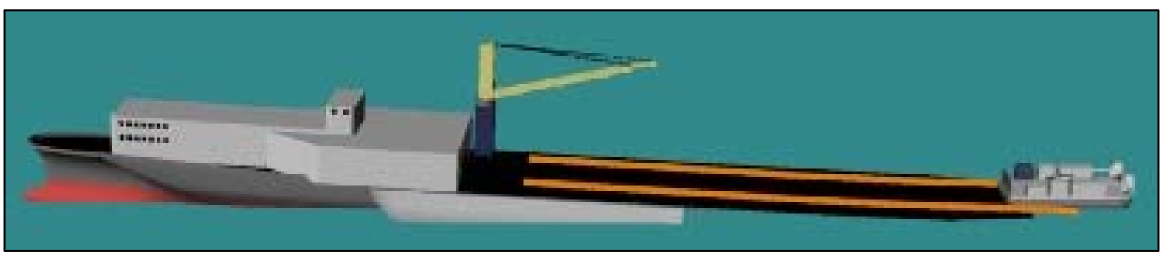

Figure 6: Phase 3 of LCAC Loading

3.6 RSTS Mission Capabilities

With a large working deck area, the RSTS can perform a wide variety of operations. The RSTS was designed to carry a cargo weight of 1,240 mt, sufficient to carry four fully loaded LCACs. Returning LCACs can be reloaded with land vehicles from the RSTS vehicle stowage area (Figure 18). The vehicle storage area contains two decks with access by a ramp in the center bow section. The ship was designed primarily to carry LCACs and land vehicles, but it can also carry a large variety of cargo such as helicopters and ISO containers.

3.7 At-Sea Interfaces

The RSTS can interface with Military Sealift Command (MSC) ships, such as the LMSR, while at sea. Using the RSTS starboard crane, the LMSR cranes, or the LMSR port ramp, vehicles can be transferred when the ships are skin-to-skin. A specific crane model was not selected for the RSTS, but it should have the capacity to lift a M1A1 tank from another ship during an at-sea transfer. An analysis of the heel of the ship due to lifting a M1A1 tank is presented at Annex G. An illustration of crane and ramp operations is at Figure 18.

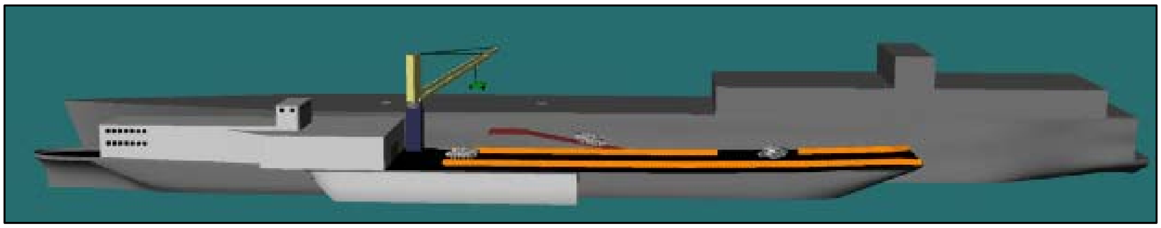

Figure 7: RSTS and LMSR interface

(Note: the LMSR cranes are not shown)

3.8 Powering and Propulsion

A fully Integrated Power System was chosen for this ship because it would allow for flexible placement of the prime movers. Azimuthing propulsion pods were chosen to provide the maneuverability needed for skin-to-skin interface. Annex H contains more information on the engine specifications and the power calculations.

3.9 Seakeeping

Due to time constraints, a seakeeping analysis was not performed. It is believed that the RSTS's trimaran design will allow operations to occur at sea state 5. Seakeeping generalizations were based on existing trimarans such as the RV Triton.

3.10 Other features

It is assumed that the ship would be manned by MSC civilian mariners. For this reason, merchant standard commercial accommodations were provided.

3.11 Principal Characteristics

The RSTS is based on the concept of a trimaran with amidships located side hulls. The intention was for a vessel with low waterplane area at the stern to allow a relatively small ballast system. Also, the limited main and side hull beam meant that seakeeping performance was not compromised by the need to provide a large main hull beam.

The principal characteristics of the design are shown at Table 2.

Principal Characteristics	
Length Overall (m)	221
Beam Overall (m)	30
Draft (m)	7
Displacement (mt)	11,400
Cargo Weight (mt)	1,240
Working Deck Area (m2)	3,900
Installed Power (MW)	17
Speed (knots)	20
Range (nm)	8,500
LCAC	4
Accommodations	50 Crew
	450 Marines
Hull Material	Steel
Ballast Tanks	3,300m^3 Keel Ballast
	4,000m^3 Stern Ballast

Table 2: Principal Characteristics

The side hull characteristics are detailed at Table 3 and the main hull characteristics are detailed at Table 4.

Side Hull Characteristics	
Length (m)	66
Beam (m)	3
Draft (m)	2
Freeboard (m)	8
C_b	0.45
C_p	0.5
C_w	0.66

Table 3: Side Hull Characteristics

Main Hull Characteristics	
Length (m)	221
Beam (m)	14
Draft (m)	7
Freeboard (m)	8
C_b	0.5
C_p	0.55
C_w	0.71
L/D	14.7

Table 4: Main Hull Characteristics

The trimaran design was analyzed and hydrostatics are shown in Table 5. An analysis of the GMt during ballasting is at Annex G.

Unballasted Condition	
GMt (m)	2.1
BMt (m)	6.75
KB (m)	4.2
KG (m)	9
MTcm	304.4
TPC	22.52

Table 5: Ship Hydrostatics

3.12 Weight Summary

The weight of the ship was estimated by scaling from existing ships. The weights of known equipment or structures were then added to the ship weight. A 7% margin was used in the weight estimations. A weight summary is shown in Table 6 and a detailed breakdown of each weight group can be found in Annex E.

Weight Group	**Weight (tonnes)**	
100 Structures	4,929	
200 Propulsion	679	
300 Electric Plant	352	
400 Command and Control	157	
500 Auxiliary Systems	1,101	
600 Outfit/Furnishings	633	
700 Armament	0	
Light Ship	7,851	
Light Ship (with 7% margin)	**8,400**	
Deadweight	2,977	
Ballast	0	7,500
Full Load Displacement	**11,374**	**18,877**

Table 6: Weight Summary

3.13 Stability

Curves of form and a GZ curve were developed for the RSTS. The curves of form can be found at Annex G and the GZ curve is shown in Figure 8. The maximum GZ is 1.2 m, which occurs at 36°. Some key points on the GZ curve are also noted in Figure 8.

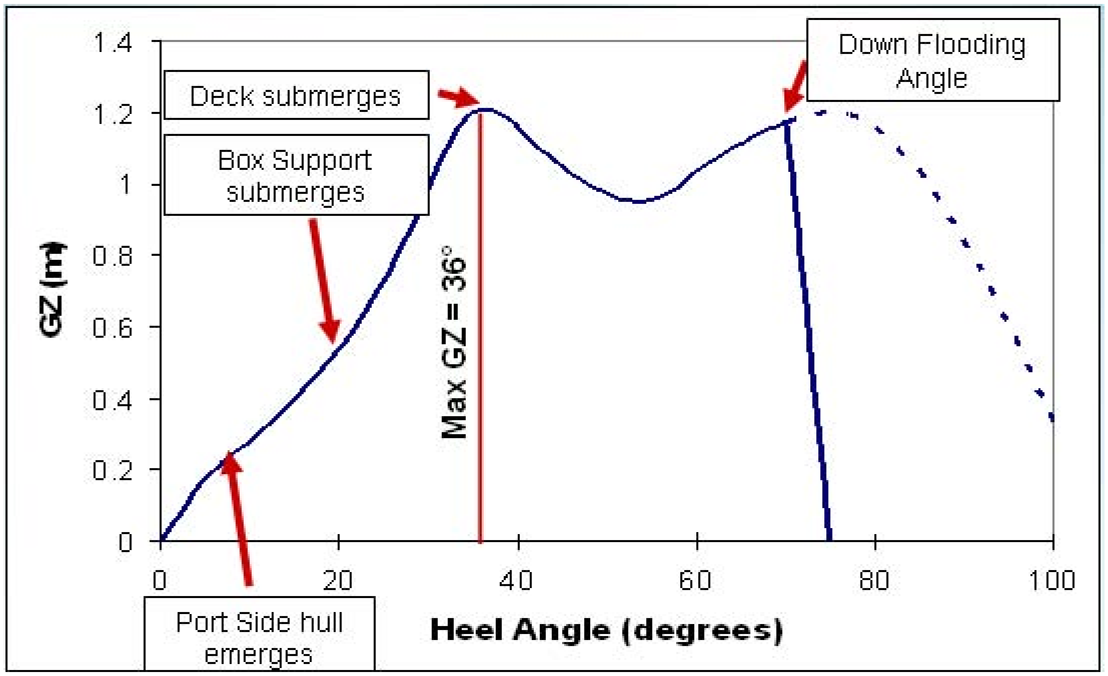

Figure 8: GZ Curve

As shown in the figure above, the side hull begins to emerge from the water at 12 degrees of heel. At 20 degrees of heel, the box structure begins to submerge under the water. Next, at 36 degrees of heel, the maximum GZ occurs and the main deck begins to submerge. Finally, the downflooding angle is reached at 70 degrees of heel.

Given the critical nature of ballasting operations for the RSTS, a stability analysis was performed for all the ballasting phases. Solid GMt calculations were undertaken and the KG was calculated at Phase 0, Phase 1, and Phase 3. For Phase 2, the KG had to be estimated due to uncertainty in the water level within the ballast tanks.

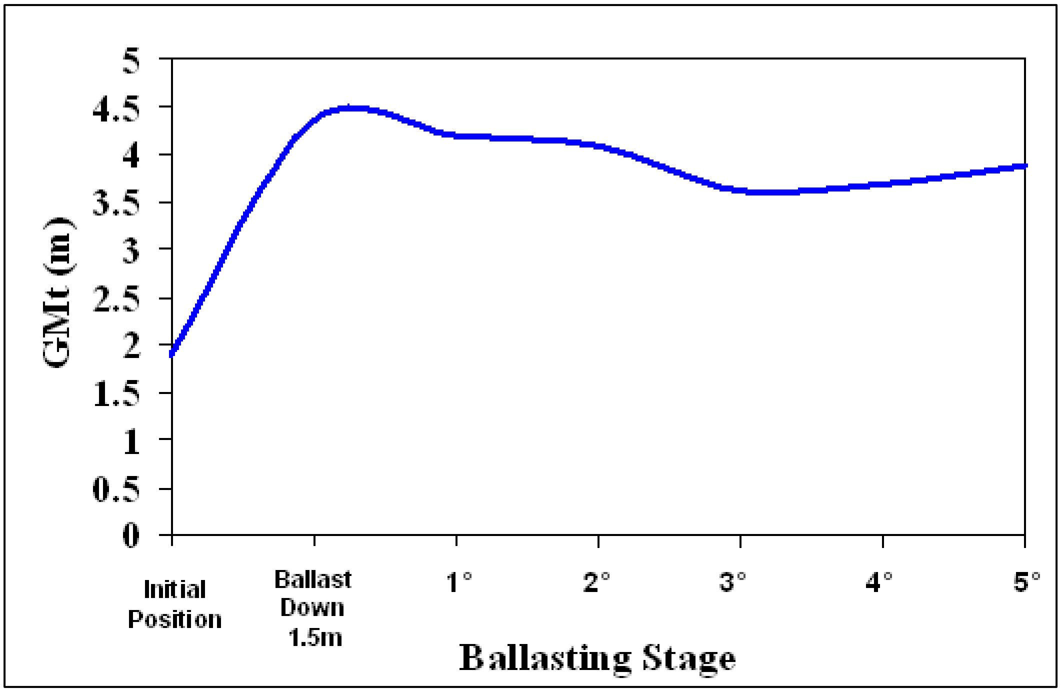

Figure 9: Ballasting Stability

It can be seen in Figure 9 that the RSTS is very stable throughout the ballasting process. As RSTS ballasts and trims, it was expected that the GMt would rise then gradually decrease. At approximately 3.5° of trim, the GMt begins to increase again. It is at this point that the main deck begins to submerge, but has not reached the point when it is under the water surface. The RSTS needs to trim by 0.5° more for the water to flood onto the main deck to support LCAC operations. Figure 9 also shows that the GMt is 3.7 m at 4° of trim, which suggests the RSTS is stable during the final stage of LCAC operations. The GMt does not drop below 1.5m at any stage of the ballasting process.

The GZ curve was corrected to incorporate the lifting of a M1A1 tank at 30m reach by the starboard crane. The corrected GZ curve is located in Figure 22. The RSTS will heel 10° starboard if the crane is lifting a M1A1 tank, which was determined to be the largest load seen by the crane.

3.14 Powering and Propulsion

The power requirement for the ship was calculated using the method of Holtrop-Mennen (See Annex C). Electrical service load was estimated to be 25% of propulsion power (3 MW). This resulted in a total power requirement of 14.8 MW to achieve a maximum service speed of 20 knots. Two Wärtsillä Genset 12V38s were used for weight calculations and provide 8.4 MW each, resulting in a total installed power of 16.8 MW (See Annex H). The additional 2 MW of installed power allows a maximum service speed of 21 knots (Figure 10).

Figure 10: Total Power Requirement versus Speed

It was assumed that there would be no tugboats for skin-to-skin operations. As a result, azimuthing thrusters located at bow and stern may be necessary to provide maneuverability. In Figure 14, Figure 15, and Figure 17, a single pod can be seen on the keel towards the stern of the ship.

4.0 Summary

The RSTS ship concept provides a dedicated LCAC carrier that has the ability to act as a transfer platform as well as a transport ship. The ship carries 4 LCACs on a large flat working deck and has additional cargo space for enough vehicles to fill 4 empty LCACs. It is intended that the ship will be able to safely perform all operations at sea state 5; this includes transiting, ballasting and de-ballasting. This is achieved by the good seakeeping characteristics provided by a trimaran hullform. The ship ballasts and trims by the stern to load and offload LCACs from the water and can also act as a transfer platform by performing skin-to-skin operations with another ship.

This ship concept exceeds the design requirements for operational capabilities because it can carry a variety of cargo. The large flat working deck provides a large amount of cargo space that could contain, but is not limited to: ISO containers, small craft, and helicopters. In addition, the installed power will allow the ship to cruise comfortably at 20 knots.

5.0 Recommendations

This project encompasses concept preliminary design work and further refinement of the concept must be undertaken in all areas. Some major areas for consideration as a part of continued design include:

- Structural analysis due to bending loads in the box structures.
- Hullform optimization.
- Damage stability.
- Electrical load refinement.
- Seakeeping.

As a priority, the seakeeping analysis should determine that this ship concept will meet the operation requirements. Seakeeping motions, especially pitch, will have a large impact on the envelope of operations. In addition to the RSTS seakeeping, analysis of smaller vessels in the lee of the RSTS during transfer operations should be undertaken to verify ship-to-ship transfer can be completed safely. In parallel with the seakeeping analysis, verification that the LCAC could climb the working deck in a seaway is required.

A modular space system was considered to allow for easy reconfiguration of the two vehicle decks. This would allow the ship to be rigged for a large variety of missions and cargo, and would greatly increase the operational capabilities of the ship. To illustrate, if the ship were transporting and delivering helicopters, modules with spare parts and tools specifically for the helicopters could be placed in the vehicle decks to provide support. Alternatively the permanent berthing for the 450 marines could be replaced by a modular system. If the berthing volume was relocated to the vehicle decks, it would increase the potential carrying capacity of the ship. If berthing was needed, berthing modules could be placed in the vehicle decks.

Analysis of the design requirements is recommended to optimize the efficiency of the ship. It may be advantageous to carry additional LCACs on the working deck, as this would lengthen the ship and reduce the working deck angle. Also, the increase in ship size may allow for additional ballast tanks that could increase the ballast capabilities of the ship.

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Annex A - Transformable Heavy Lift Ship Project Requirements

Introduction

Current Heavy Lift Ships are focused on the slow speed, safe delivery of large mass and size cargos to a point of offload as bespoke operations. The seakeeping and powering performance of these vessels is not optimized and extremely limiting limitations in operating sea state and speed are accepted to allow greater capacity.

In a military environment it is not acceptable to delay offload operations due to the presence of moderate seas, or to sail at slow speeds to the operational theatre. However the cargo to be offloaded is less dense than commercial cargos. There is a role for a dedicated Heavy Lift ship / Semi Submersible vessel design, focused on allowing the offload of relatively light density amphibious vessels in widely varying environmental conditions.

Aim

To identify a ship design capable of fulfilling the role of a semi-submersible vessel for amphibious connectors such as LCACs, or operating as a heavy lift ship, while providing excellent seakeeping characteristics in both ballasted and unballasted modes and good powering performance at fleet operational speeds.

The primary objective of this Innovation Cell is to investigate possible vessel configurations that should allow these conflicting requirements to be met. A ship design based on the most promising configuration should be developed.

Ship Design Requirements

To allow trans-oceanic transportation of 4-6 LCACs from the US, along with an appropriate quantity of US Marine Corps Marine Expeditionary Brigade Vehicles without weather routing.

To allow the vehicles to be loaded onto the LCACs with the vessel in the ballasted mode in Seas State 5.

To ballast the vessel to allow the offload and onload of loaded and empty LCACs in Sea State 5.

To de-ballast the vessel and sail to a local port for refueling.

Areas Of Technology Exploration

Identification of hullform geometry and structural arrangements to allow good seakeeping (notably heave, roll and pitch) in both operating modes without compromise to propulsive performance, transport and offload capabilities.

Identification of variable geometry hullforms and structural arrangements.

Development of a ship design with characteristics that demonstrate these capabilities.

Constraints

The vessel would ideally be limited to traditional PANAMAX requirements.

The vessel shall use steel as the main constructive material.

Extant propulsion technology shall be used.

Approach

The team will review requirements and then brainstorm potential ideas.

A review of potential concept hullforms for feasibility and hydrodynamic performance shall be undertaken.

The team will use a mission effectiveness assessment to down select one or more concepts which they will then develop further to establish a concept ship design and identify technology development needs for the concept.

Deliverables

All work will be documented in a CISD Project Technical Report. The final report and presentation shall be suitable for unclassified, public release.

During the first 2 weeks the team will produce a team project plan of actions, assignments and milestones.

The team will develop and give informal intermediate presentations and a final project presentation.

The resulting ship design shall be detailed including a single sheet summary of characteristics, a comprehensive SWBS breakdown, a hullform body plan and a full general arrangement drawing.

The team will be encouraged to produce a technical paper from the final report that would be published at a professional society conference in the future.

Annex B – RSTS Renderings

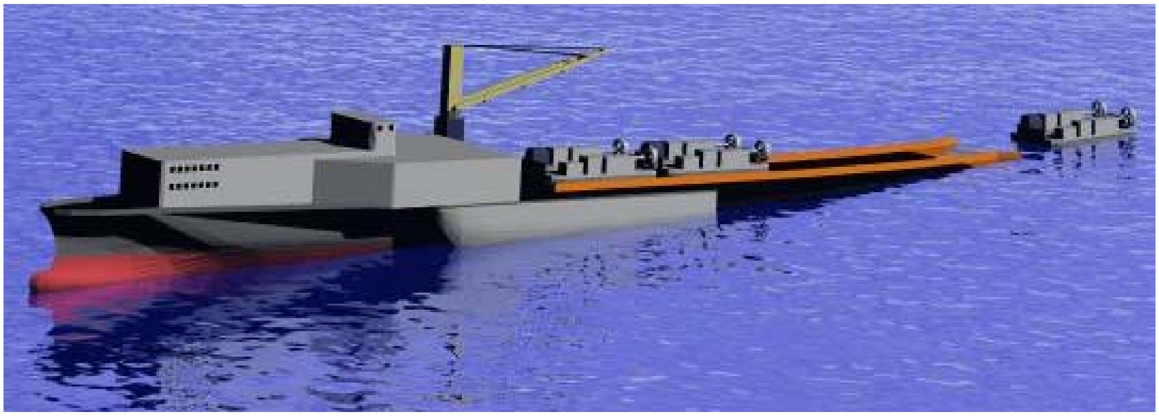

Figure 11: LCAC Loading 1

Figure 12: LCAC loading 2

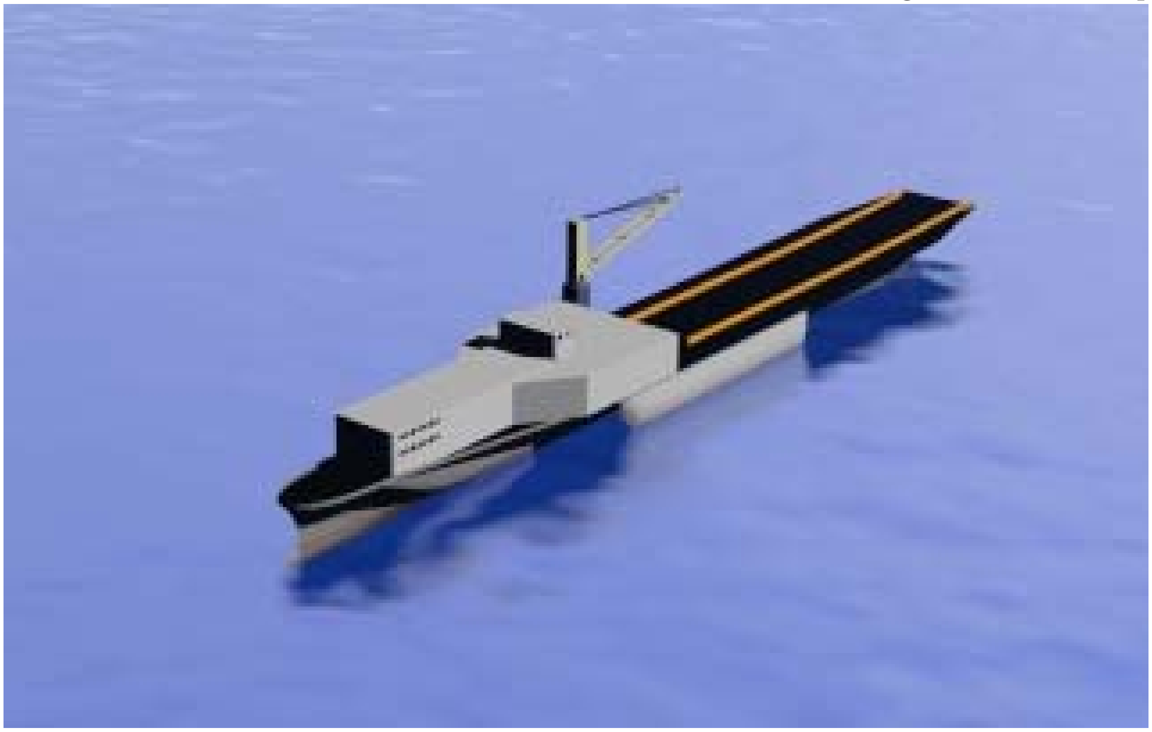

Figure 13: Overview 1

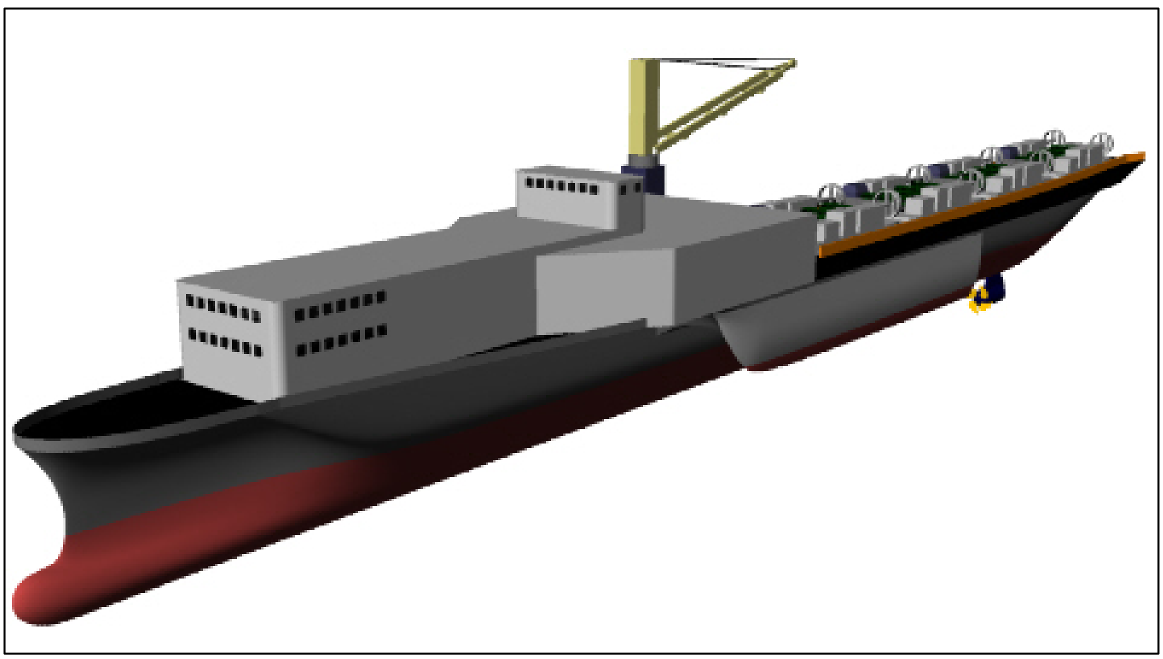

Figure 14: Overview 2

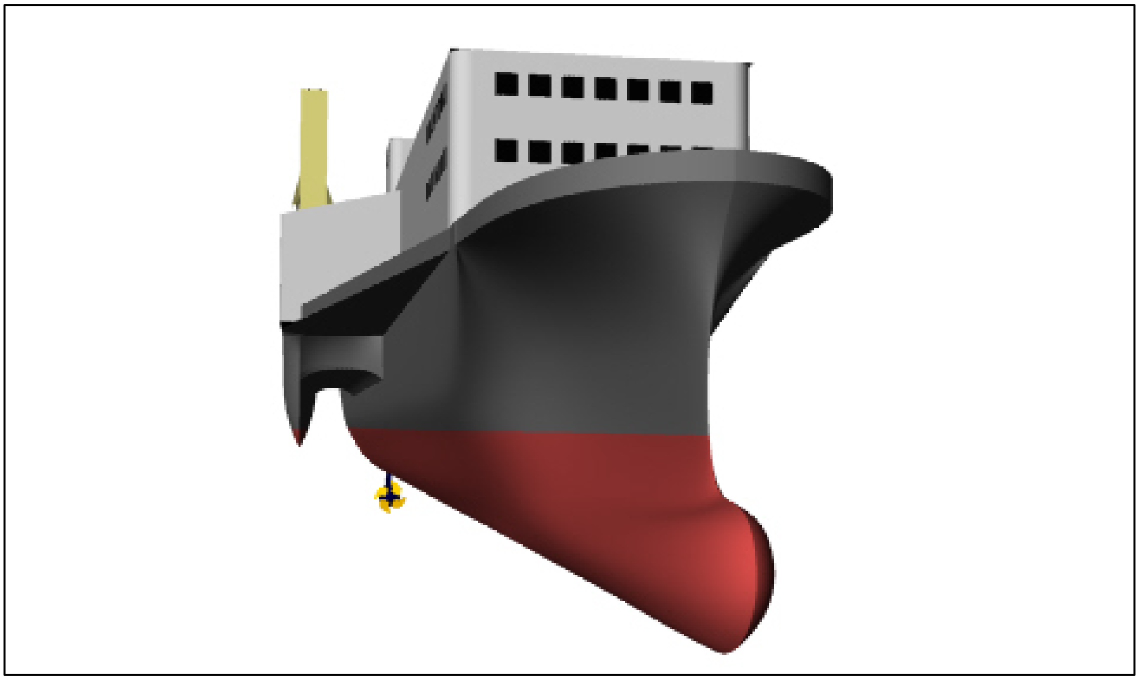

Figure 15: Bow View

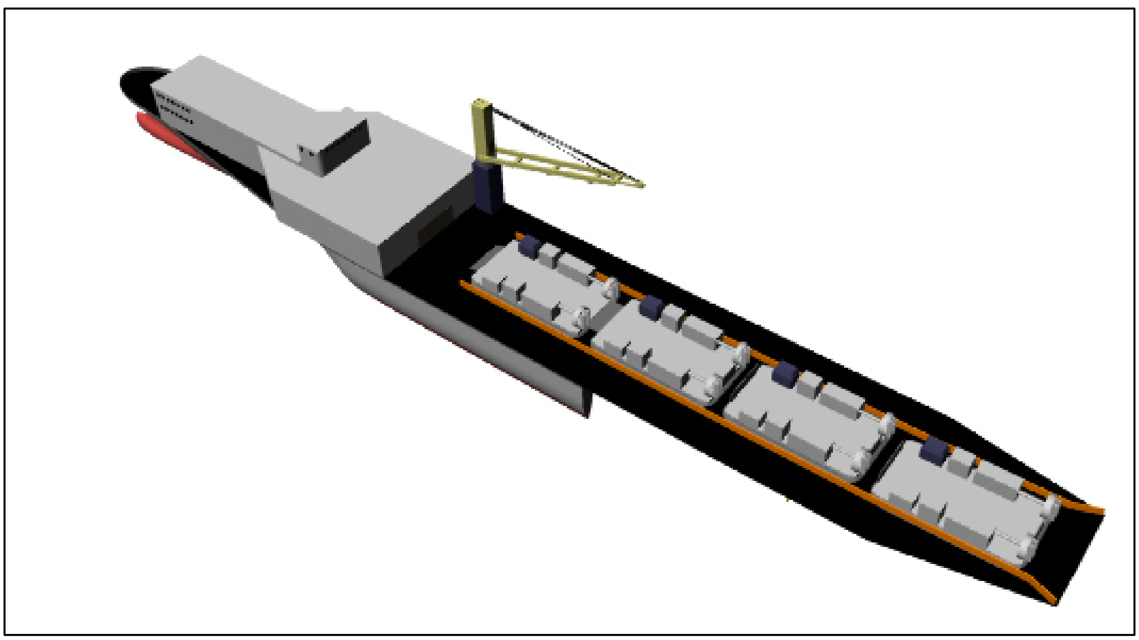

Figure 16: Top View

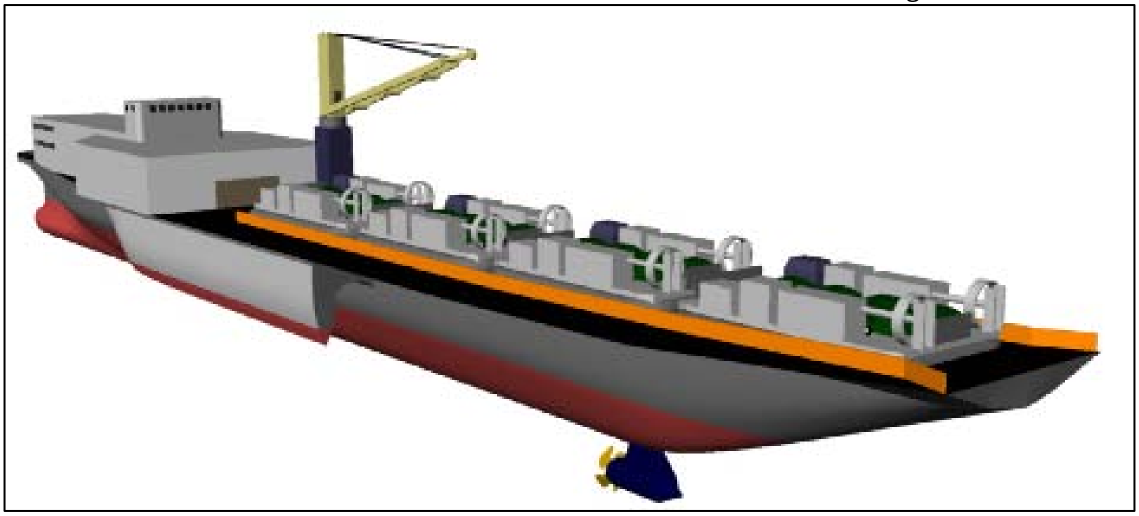

Figure 17: Stern View

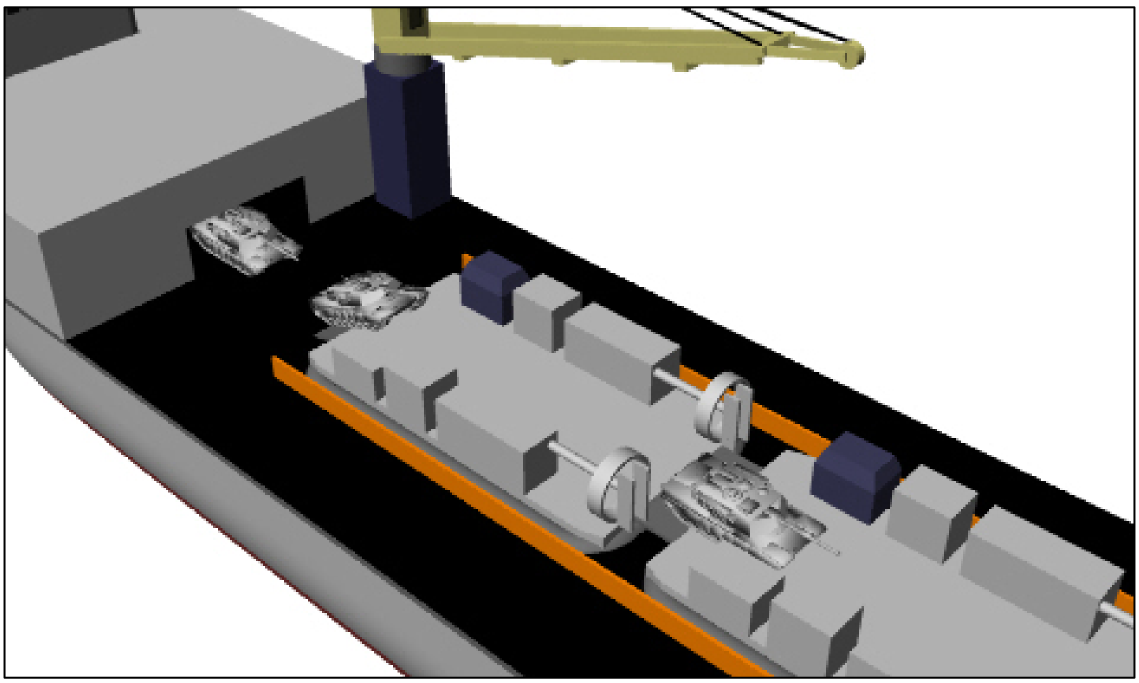

Figure 18: Vehicle Transfer

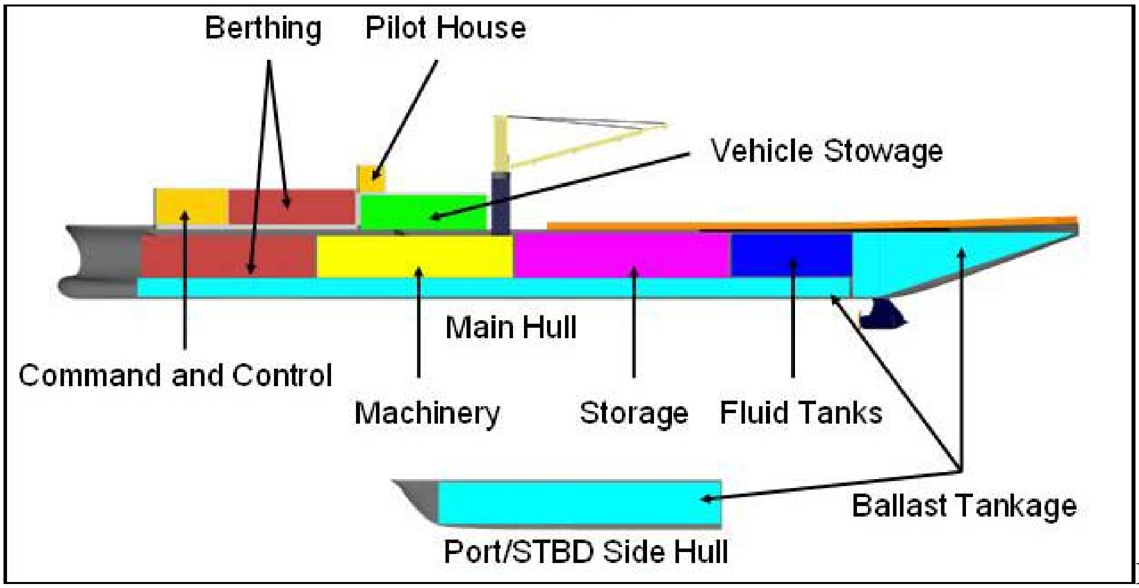

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Figure 19: General Hull Arrangement

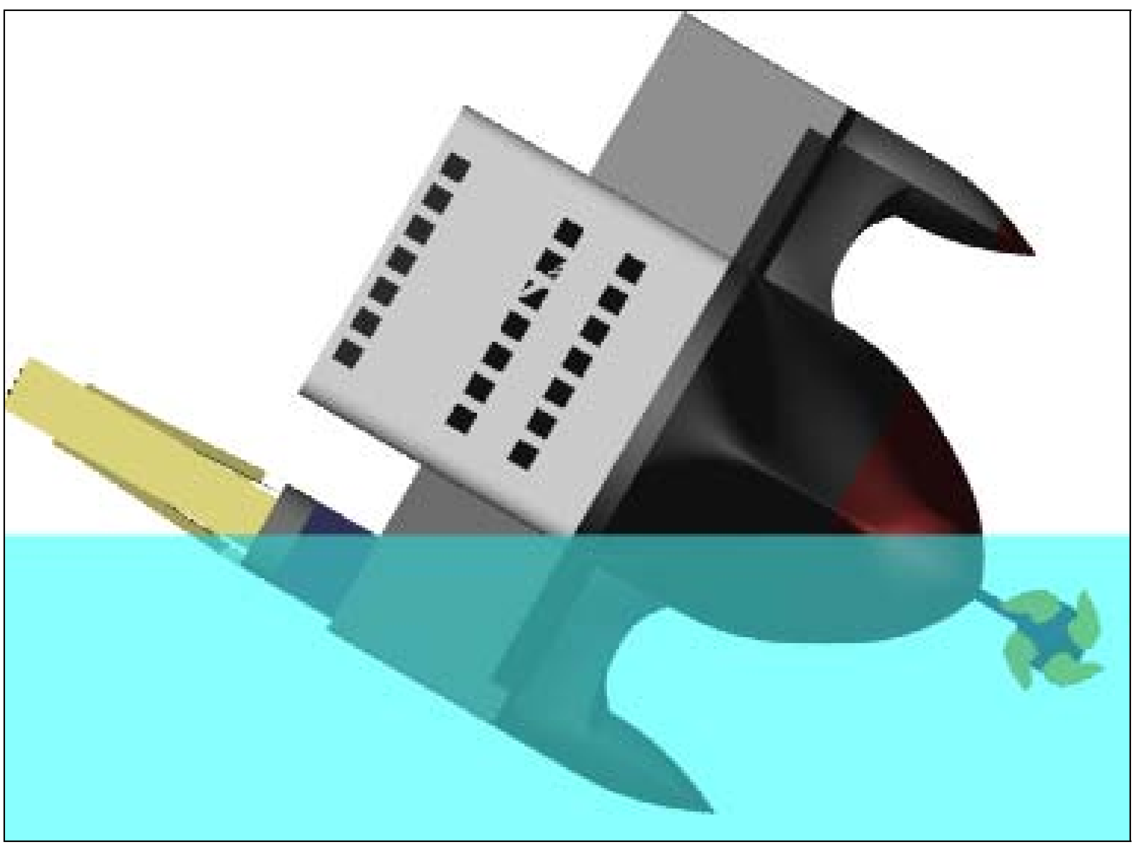


Figure 20: Ship, 70° of Heel

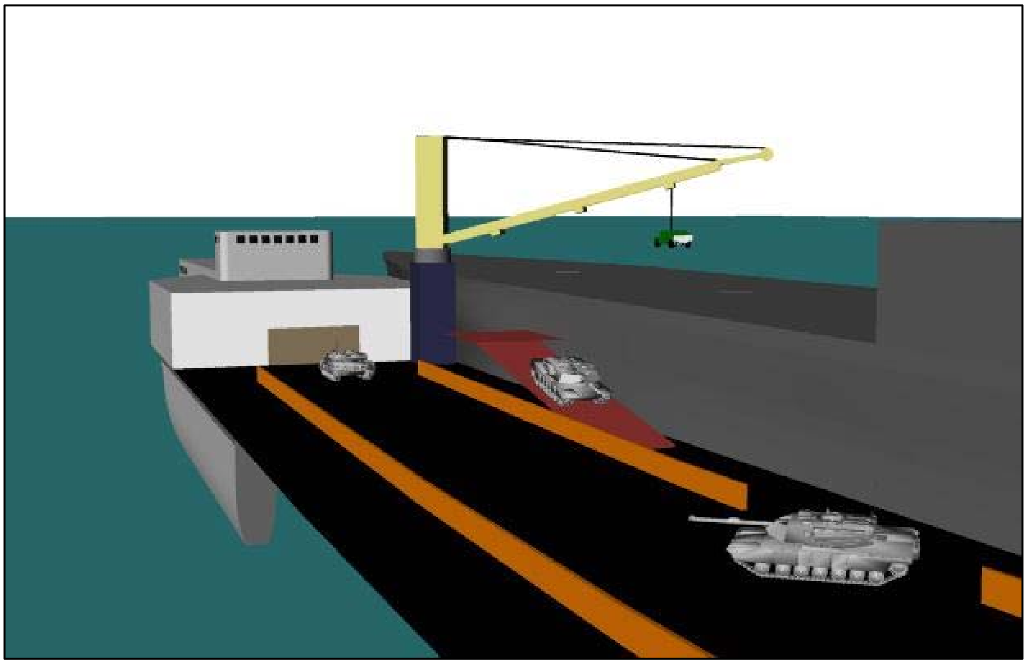


Figure 21: Port Ramp Interface with LMSR

Annex C – Resistance and Powering Calculations

Main Hull

(Calculation method based on Reference 4.)

Inputs	
Length (m)	221.09
Circ M	10.03
Beam (m)	14.00
Draught (m)	6.91
B/L	0.063
T/L	0.031
B/T	2.03
LCB/L	0.050
Cp	0.55
Cm	0.75
Cw	0.71
Cb	0.5
Abulb/BT	0.35

Wave Resistance			
Fn	0.221	lamda	0.435
C4	0.092	r bulb (m)	1.000
ie	1.497	i bulb (m)	5.467
C1- FnHigh	0.3732	C2	0.644
C1- FnLow	0.2546	Ctransom	0.05
d	-0.9	C3	0.96
C5	1.411	Rw/W (0.4)	0.0069
m1low	-1.440	Rw/W (0.55)	0.0085
m1high	-1.906	Rw/W(low)	0.0006
C6	-0.832	Rw/W(high)	0.0001
m2	-0.002	Rw/W	0.001
m2(0.4)	-0.166	Rw	36.51
m2(0.55)	-0.261		
Viscous Resistance			
Rn	1.91E+09	1+k	1.045
Cfo	1.4E-03	Abulb	33.87
Lr / L	0.451	S	3969.8
L^3/ V	1010.1	Rv	317.87
Correlation Allowance		Total Resistance	
Ca	0.00034	Rt (kN)	427.17

Side Hulls

Inputs	
Length (m)	66.33
Circ M	11.83
Beam (m)	3.00
Draught (m)	2.07
B/L	0.045
T/L	0.031
B/T	1.45
LCB/L	0.050
Cp	0.5
Cm	0.57
Cw	0.67
Cb	0.45
Abulb/BT	0

Wave Resistance			
Fn	0.403	lamda	0.363
C4	0.082	r bulb (m)	1.000
ie	1.025	i bulb (m)	0.628
C1- FnHigh	0.3378	C2	1.000
C1- FnLow	0.2377	Ctransom	0.05
d	-0.9	C3	0.96
C5	1.446	Rw/W (0.4)	0.0103
m1low	-1.362	Rw/W (0.55)	0.0089
m1high	-2.094	Rw/W(low)	0.0105
C6	-0.071	Rw/W(high)	0.0028
m2	-0.014	Rw/W	0.010
m2(0.4)	-0.014	Rw	2.31
m2(0.55)	-0.022		
Viscous Resistance			
Rn	5.74E+08	1+k	1.019
Cfo	1.6E-03	Abulb (m^2)	0
Lr / L	0.502	S (m^2)	261.6
L^3/ V	1655.6	Rv (kN)	23.17
Total Resistance		**Correlation Allowance**	
Rt (kN)	34.52	Ca	0.00060

Summary

Inputs	
Max Service Speed (knots)	20
Density (kg/m^3)	1025
Kinematic Viscosity (m^2/s)	1.188E-06
Results	
Rt (kN)	545.83
Pe (MW)	5.61
Pea (MW)	6.17
Ps (MW)	9.50
Sea Margin (%)	25
Ps (MW)	11.87
Service Load (%)	25
Total Power Requirement (MW)	14.84

Annex D – Hull Size Calculations

Input Parameters			
Main Hull		**Side Hull**	
Depth (m)	0	Beam	3
Beam ov (m)	30	L sh / L mh	0.3
Beam (m)	14	T sh / T mh	0.3
Beam MH/Beam ov	0.467	**B sh / B ov**	0.1
Kf	1.1	Kf	1.25
Cb	0.5	Cb	0.45
Cp	0.55	Cp	0.5
Cm	0.91	**Cm**	0.900
Cw	0.710	Cw	0.667
Cit	0.518	Cit	0.457
Box		**Superstructure**	
Box Height Required	3	VS	0.2798
Box ht / D mh	0.200	Ksl	0.3
B box / B ov	0.267		
Box Wet Deck Clearance (m)	5.09		
Hull Sep / B ov	0.17		
L box / L = L sh / L	0.3		
Derived Parameters			
Length (m)	221.1	Volume (m^3)	49268
Beam (m)	30.0	Displacement Volume (m^3)	11069.55
Superstructure		Box Structure	
Volume (m^3)	13787.04	Box Volume (m^3)	3183.64
Length (m)	66.33	Hull Separation (m)	5.00
Depth (Average) (m)	14.85	Box Wet Deck Clearance (m)	5.09
Depth + Freeboard (m)	22.94	*Box Length (m)*	66.33
Main Hull		e = Hbx/D*Bbox/B*Lbox/L	0.016
Volumes		Side Hull (Both)	
Volume (m^3)	30239.05	*Volumes*	
Displacement (m^3)	10698.18	Volume (m^3)	2058.46
Dimensions		Displacement (m^3)	185.69
Beam (m)	14.00	Displacement Prop (2 .	0.03
Draught (m)	6.91		
Freeboard (m)	8.09		
Dimension Ratios		*Dimensions*	
Circ M	10.03	Length (m)	66.33
L/B	15.79	Beam (m)	3.00
B/T	2.03	Draught (m)	2.07
B/D	0.93	Freeboard	8.09
D/T	2.170	L/B	22.11
L/D	14.74	B/T	1.45

Annex E – Detailed Weight Breakdown

		Mton
100 HULL STRUCTURES*[*]	TOTAL	4,929.16
200 PROPULSION PLANT	TOTAL	679.782
210 ENERGY GEN SYS (NUCLEAR)	SUBTOTAL	0
220 ENERGY GENERATING SYSTEM (NONNUC)	SUBTOTAL	0
221 PROPULSION BOILERS		
222 GAS GENERATORS		
223 MAIN PROPULSION BATTERIES		
224 MAIN PROPULSION FUEL CELLS		
230 PROPULSION UNITS	SUBTOTAL	248
231 STEAM TURBINES		
232 STEAM ENGINES		
233 DIESEL ENGINES		248
234 GAS TURBINES		
235 ELECTRIC PROPULSION		
236 SELF-CONTAINED PROPULSION SYS		
237 AUXILIARY PROPULSION DEVICES		
240 TRANSMISSION+PROPULSOR SYSTEMS	SUBTOTAL	219.46
241 REDUCTION GEARS		0
242 CLUTCHES + COUPLINGS		0
243 SHAFTING		0
244 SHAFT BEARINGS		0
245 PROPULSORS		
246 PROPULSOR SHROUDS AND DUCTS		
247 WATER JET PROPULSORS		
250 SUPPORT SYSTEMS	SUBTOTAL	78.11
251 COMBUSTION AIR SYSTEM		
252 PROPULSION CONTROL SYSTEM		
253 MAIN STEAM PIPING SYSTEM		
254 CONDENSERS AND AIR EJECTORS		
255 FEED AND CONDENSATE SYSTEM		
256 CIRC + COOL SEA WATER SYSTEM		
258 H.P. STEAM DRAIN SYSTEM		
259 UPTAKES (INNER CASING)		
260 PROPUL SUP SYS- FUEL, LUBE OIL	SUBTOTAL	52.62
261 FUEL SERVICE SYSTEM		
262 MAIN PROPULSION LUBE OIL SYSTEM		
264 LUBE OIL HANDLING		

[*] The subgroups are not included because the entire SWBS 100 Group was scaled directly from the LPD-17

290 SPECIAL PURPOSE SYSTEMS	SUBTOTAL	81.60
298 OPERATING FLUIDS		
299 REPAIR PARTS + TOOLS		
300 ELECTRIC PLANT, GENERAL	TOTAL	352.81
310 ELECTRIC POWER GENERATION	SUBTOTAL	149.9357
311 SHIP SERVICE POWER GENERATION		
312 EMERGENCY GENERATORS		
313 BATTERIES+SERVICE FACILITIES		
314 POWER CONVERSION EQUIPMENT		
320 POWER DISTRIBUTION SYS	SUBTOTAL	107.4218
321 SHIP SERVICE POWER CABLE		
322 EMERGENCY POWER CABLE SYS		
323 CASUALTY POWER CABLE SYS		
324 SWITCHGEAR+PANELS		
330 LIGHTING SYSTEM	SUBTOTAL	36.38345
331 LIGHTING DISTRIBUTION		
332 LIGHTING FIXTURES		
340 POWER GENERATION SUPPORT SYS	SUBTOTAL	44.5708
341 SSTG LUBE OIL		
342 DIESEL SUPPORT SYS		
343 TURBINE SUPPORT SYS		
390 SPECIAL PURPOSE SYS	SUBTOTAL	14.5013
398 ELECTRIC PLANT OP FLUIDS		
399 REPAIR PARTS+SPECIAL TOOLS		
400 COMMAND & CONTROL	TOTAL	157.89
410 COMMAND+CONTROL SYS	SUBTOTAL	31.72
411 DATA DISPLAY GROUP		6.50
412 DATA PROCESSING GROUP		9.80
413 DIGITAL DATA SWITCHBOARDS		1.20
414 INTERFACE EQUIPMENT		0.00
415 DIGITAL DATA COMMUNICATIONS		58.44
417 COMMAND+CONTROL ANALOG SWBD		0.00
420 NAVIGATION SYS	SUBTOTAL	8.01
421NON-ELECT NAVIGATION AIDS		0.28
422 ELECTRICAL NAVIGATION AIDS		0.17
423ELECTRONIC NAVIG AIDS, RADIO		2.91
424 ELECTRONIC NAVIG AIDS, ACOUSTIC		0.55
426 ELECTRICAL NAVIGATION SYS		4.09
427 INERTIAL NAVIGATION SYS		0.00
428 NAVIGATION CONTROL MONITORING		0.00
430 INTERIOR COMMUNICATIONS	SUBTOTAL	53.24
431 SWITCHBOARDS FOR I.C. SYSTEMS		0.11

432 TELEPHONE SYSTEMS		68.51
433 ANNOUNCING SYSTEMS		10.97
434 ENTERTAINMENT + TRAINING SYS		12.11
435 VOICE TUBES+MESSAGE PASSING SYS		0.00
436 ALARM, SAFETY, WARNING SYSTEMS		7.93
437 INDICATING, ORDER, METERING SYS		6.79
438 INTEGRATED CONTROL SYSTEMS		21.04
439 RECORDING + TELEVISION SYSTEMS		0.00
440 EXTERIOR COMMUNICATIONS	SUBTOTAL	46.45
441 RADIO SYSTEMS		45.93
442 UNDERWATER SYSTEMS		0.00
443 VISUAL + AUDIBLE SYSTEMS		0.53
444 TELEMETRY SYSTEMS		0.00
445 TTY + FACSIMILE SYSTEMS		0.00
446 SECURITY EQUIPMENT SYSTEMS		0.00
450 SURF SURV SYS (RADAR)	SUBTOTAL	0.00
451 SURFACE SEARCH RADAR		0.13
452 AIR SEARCH RADAR (2D)		2.01
453 AIR SEARCH RADAR (3D)		16.10
454 AIRCRAFT CONTROL APPROACH RADAR		0.00
455 IDENTIFICATION SYSTEMS (IFF)		2.01
456 MULTIPLE MODE RADAR		0.00
459 SPACE VEHICLE ELECTRONIC TRACKG		0.00
460 UNDERWATER SURVEILLANCE SYSTEMS	SUBTOTAL	0.00
461 ACTIVE SONAR		0.00
462 PASSIVE SONAR		0.00
463 MULTIPLE MODE SONAR		0.00
464 CLASSIFICATION SONAR		0.00
465 BATHYTHERMOGRAPH		0.00
466 MISC ELECTRONICS		0.00
470 COUNTERMEASURES	SUBTOTAL	0.00
471 ACTIVE + ACTIVE/PASSIVE ECM		2.06
472 PASSIVE ECM		0.02
473 TORPEDO DECOYS		3.97
474 DECOYS (OTHER)		4.38
475 DEGAUSSING		184.89
476 MINE COUNTERMEASURES		0.00
480 FIRE CONTROL SYS	SUBTOTAL	0.00
481 GUN FIRE CONTROL SYSTEMS		0.00
482 MISSILE FIRE CONTROL SYSTEMS		2.01
483 UNDERWATER FIRE CONTROL SYSTEMS		0.00

484 INTEGRATED FIRE CONTROL SYSTEMS		0.00
489 WEAPON SYSTEM SWITCHBOARDS		0.00
490 SPECIAL PURPOSE SYS	SUBTOTAL	18.46
491 ELCTRNC TEST,CHKOUT,MONITR EQPT		0.19
492 FLIGHT CNTRL+INSTR LANDING SYS		0.00
493 NON-COMBAT DATA PROCESSING SYS		10.77
494 METEOROLOGICAL SYSTEMS		0.00
495 SPEC PURPOSE INTELLIGENCE SYS		0.00
496 OPERATION SPACE ITEMS		0.00
498 C+S OPERATING FLUIDS		0.00
499 REPAIR PARTS+SPECIAL TOOLS		7.50
500 AUXILIARY SYSTEMS, GENERAL	TOTAL	1,101.92
510 CLIMATE CONTROL	SUBTOTAL	206.94
511 COMPARTMENT HEATING SYSTEM		
512 VENTILATION SYSTEM		
513 MACHINERY SPACE VENT SYSTEM		
514 AIR CONDITIONING SYSTEM		
516 REFRIGERATION SYSTEM		
517 AUX BOILERS+OTHER HEAT SOURCES		
520 SEA WATER SYSTEMS	SUBTOTAL	165.73
521 FIREMAIN+SEA WATER FLUSHING SYS		
522 SPRINKLING SYSTEM		
523 WASHDOWN SYSTEM		
524 AUXILIARY SEAWATER SYSTEM		
526 SCUPPERS+DECK DRAINS		
527 FIREMAIN ACTUATED SERV, OTHER		
528 PLUMBING DRAINAGE		
529 DRAINAGE+BALLASTING SYSTEM		
530 FRESH WATER SYSTEMS	SUBTOTAL	99.51
531 DISTILLING PLANT		
532 COOLING WATER		
533 POTABLE WATER		
534 AUX STEAM + DRAINS IN MACH BOX		
535 AUX STEAM + DRAINS OUT MACH BOX		
536 AUXILIARY FRESH WATER COOLING		
540 FUELS/LUBRICANTS,HANDLING+STORAGE	SUBTOTAL	69.48

541 SHIP FUEL+COMPENSATING SYSTEM		
542 AVIATION+GENERAL PURPOSE FUELS		
543 AVIATION+GENERAL PURPOSE LUBO		
544 LIQUID CARGO		
545 TANK HEATING		
546 AUXILIARY LUBE SYS		
549 SPEC FUEL+LUBRICANTS HANDL+STOW		
550 AIR,GAS+MISC FLUID SYSTEM	SUBTOTAL	137.81
551 COMPRESSED AIR SYSTEMS		
552 COMPRESSED GASES		
553 O2 N2 SYSTEM		
554 LP BLOW		
555 FIRE EXTINGUISHING SYSTEMS		
556 HYDRAULIC FLUID SYSTEM		
557 LIQUID GASES, CARGO		
558 SPECIAL PIPING SYSTEMS		
560 SHIP CNTL SYS	SUBTOTAL	56.59
561 STEERING+DIVING CNTL SYS		
562 RUDDER		
565 TRIM+HEEL SYSTEMS		
568 MANEUVERING SYSTEMS		
570 UNDERWAY REPLENISHMENT SYSTEMS	SUBTOTAL	106.45
571 REPLENISHMENT-AT-SEA SYSTEMS		
572 SHIP STORES+EQUIP HANDLING SYS		
573 CARGO HANDLING SYSTEMS		
574 VERTICAL REPLENISHMENT SYSTEMS		
575 VEHICLE HANDLING+STOWAGE SYSTEMS		
580 MECHANICAL HANDLING SYSTEMS	SUBTOTAL	96.70
581 ANCHOR HANDLING+STOWAGE SYSTEMS		
582 MOORING+TOWING SYSTEMS		
583 BOATS,HANDLING+STOWAGE SYSTEMS		
584 MECH OPER DOOR,GATE,RAMP,TTBL SYS		
585 ELEVATING + RETRACTING GEAR		
586 AIRCRAFT RECOVERY SUPPORT SYS		
587 AIRCRAFT LAUNCH SUPPORT		

SYSTEM		
588 AIRCRAFT HANDLING,SERVICE,STOWAGE		
589 MISC MECH HANDLING SYSTEMS		
590 SPECIAL PURPOSE SYSTEMS	SUBTOTAL	162.70
591 SCIENTIFIC+OCEAN ENGINEERING SYS		
592 SWIMMER+DIVER SUPPORT+PROT SYS		
593 ENVIRONMENTAL POLLUTION CNTL SYS		
594 SUBMARINE RESC+SALVG+SURVIVE SYS		
595 TOW,LAUNCH,HANDLE UNDERWATER SYS		
596 HANDLING SYS FOR DIVER+SUBMR VEH		
597 SALVAGE SUPPORT SYSTEMS		
598 AUX SYSTEMS OPERATING FLUIDS		
599 AUX SYSTEMS REPAIR PARTS+TOOLS		
600 OUTFIT+FURNISHING,GENERAL	TOTAL	633.04
610 SHIP FITTINGS	SUBTOTAL	101.58
611 HULL FITTINGS		
612 RAILS,STANCHIONS+LIFELINES		
613 RIGGING+CANVAS		
620 HULL COMPARTMENTATION	SUBTOTAL	184.14
621 NON-STRUCTURAL BULKHEADS		
622 FLOOR PLATES+GRATING		
623 LADDERS		
624 NON-STRUCTURAL CLOSURES		
625 AIRPORTS,FIXED PORTLTS, WINDOWS		
630 PRESERVATIVES+COVERINGS	SUBTOTAL	148.85
631 PAINTING		
632 ZINC COATING		
633 CATHODIC PROTECTION		
634 DECK COVERINGS		
635 HULL INSULATION		
636 HULL DAMPING		
637 SHEATHING		
638 REFRIGERATION SPACES		
639 RADIATION SHIELDING		
640 LIVING SPACES	SUBTOTAL	78.0
641 OFFICER BERTHING+MESSING		

642 NON-COMM OFFICER B+M		
643 ENLISTED PERSONNEL B+M		
644 SANITARY SPACES+FIXTURES		
645 LEISURE+COMMUNITY SPACES		
650 SERVICE SPACES	SUBTOTAL	26.0
651 COMMISSARY SPACES		
652 MEDICAL SPACES		
653 DENTAL SPACES		
654 UTILITY SPACES		
655 LAUNDRY SPACES		
656 TRASH DISPOSAL SPACES		
660 WORKING SPACES	SUBTOTAL	35.77
661 OFFICES		
662 MACH CNTL CENTER FURNISHING		
663 ELECT CNTL CENTER FURNISHING		
664 DAMAGE CNTL STATIONS		
665 WORKSHOPS,LABS,TEST AREAS		
670 STOWAGE SPACES	SUBTOTAL	50.07
671 LOCKERS+SPECIAL STOWAGE		
672 STOREROOMS+ISSUE ROOMS		
673 CARGO STOWAGE		
690 SPECIAL PURPOSE SYSTEMS	SUBTOTAL	8.64
698 OPERATING FLUIDS		
699 REPAIR PARTS+SPECIAL TOOLS		
700 ARMAMENT**[**]	TOTAL	0.00
800 DEADWEIGHT	TOTAL	2,977.749
SHIPS FORCE	SUBTOTAL	48.33524
OFFICERS		
NON-COMMISSIONED OFFICERS		
ENLISTED MEN		
MARINES		
TROOPS		
AIR WING PERSONNEL		
OTHER PERSONNEL		
MISSION RELATED EXPENDABLES+SYS	SUBTOTAL	0.000
SHIP AMMUNITION		
ORD DEL SYS AMMO		
ORD DEL SYS (AIRCRAFT)		
ORD REPAIR PARTS (SHIP)		
ORD REPAIR PARTS (ORD)		

[**] It is intended that no offensive weapon systems will be included on the RSTS, because it will be operated by MSC.

ORD DEL SYS SUPPORT EQUIP		
SPECIAL MISSION RELATED SYS		
STORES	SUBTOTAL	85.521
PROVISIONS+PERSONNEL STORES		
GENERAL STORES		
MARINES STORES (SHIPS COMPLEM)		
SPECIAL STORES		
LIQUIDS, PETROLEUM BASED	SUBTOTAL	1,589.64
FUEL OIL		1,530
LUBE OIL		
ARRAY FLUID		
DISTILLATE FUEL		
NAVY STANDARD FUEL OIL (NSFO)		
LUBRICATING OIL		59.64
SPECIAL FUELS AND LUBRICANTS		
LIQUIDS, NON-PETRO BASED	SUBTOTAL	14.255
SEA WATER		
FRESH WATER		
RESERVE FEED WATER		
HYDRAULIC FLUID		
SANITARY TANK LIQUID		
GAS (NON FUEL TYPE)		
MISC LIQUIDS, NON-PETROLEUM		
CARGO	SUBTOTAL	0
CARGO, ORDINANCE + DELVRY SYS		
CARGO, STORES		
CARGO, FUELS + LUBRICANTS		
CARGO, LIQUIDS, NON-PETROLEUM		
CARGO, CRYOGENIC+LIQUEFIED GAS		
CARGO, AMPHIBIOUS ASSAULT SYS		
CARGO, GASES		
CARGO, MISCELLANEOUS		
Ballast, Stern	SUBTOTAL	0
Ballast, Vert	SUBTOTAL	0
LCACS	SUBTOTAL	740
Crane	SUBTOTAL	100
Military Vehicles	SUBTOTAL	500

Annex F – Detailed Volume Breakdown

GROUP 1.1			
1.11101	COMMUNICATION CENTER	81.30	243.90
1.11102	RADIO TRANSMITTER ROOM	96.60	289.80
1.11107	COMMUNICATION CENTER-FACILITIES CONTROL AREA	48.60	145.80
1.11301	SIGNAL SHELTER	7.40	22.20
1.12	COMMUNICATION CENTER ON-LINE EQUIPMENT ROOM	17.50	52.50
1.122202	UNDERWATER LOG TRUNK	3.60	8.30
1.13	DATA AND INFORMATION SYSTEM OFFICE	13.50	40.50
1.13201	PILOT HOUSE	92.00	276.00
1.13202	CHART ROOM	16.70	50.10
1.13306	AUTOMATED DATA PROCESSING ROOM	13.30	39.90
1.15001	INTERIOR COMMUNICATIONS AND GYROCOMPASS ROOM	104.50	313.50
1.16101	ELECTRONIC COOLING EQUIPMENT ROOM	25.80	77.40
GROUP 1.2			
1.22701	SECURITY STATION	2.80	8.40
1.2804	SERVICE INTERFACE ROOM (A-SIZE MODULE)	8.00	22.80
GROUP 1.3		0.00	0.00
GROUP 1.4			
1.544	CARGO	1,248.00	5,616.00
GROUP 1.6			
1.61	ELECTRONIC SHOP NO 1 AND ELECTRONIC CALIBRATION LABRATORY	10.75	32.26
1.61	MECHANICAL CALIBRATION FACILITY	6.24	18.72
1.61401	ELECTRONIC SHOP NO 2	8.85	26.55
1.61601	INTERNAL COMBUSTION ENGINE SHOP	17.70	53.11
1.61603	VALVE REPAIR AND TEST SHOP	14.21	42.62
1.61608	HYDRAULIC SHOP	13.32	39.96
1.61807	CANVAS SHOP	9.43	28.28
GROUP 1.7		0.00	0.00
GROUP 1.8		0.00	0.00
GROUP 1.9		0.00	0.00
GROUP 2.1			
2.11111	Commanding Officer Cabin	28.00	84.00

2.11111	Commanding Officer Stateroom	20.00	60.00
2.11112	Dept Head Stateroom	12.00	36.00
2.111121	Executive Officer Stateroom	20.00	60.00
2.111122	Executive Officer Cabin	24.00	72.00
2.11113	Stateroom (2)	20.25	60.75
2.1113	Troop XO Stateroom	27.00	81.00
2.11131	Troop CO Cabin	21.00	63.00
2.11131	Troop CO Stateroom	13.00	39.00
2.11133	Troop Officer Stateroom (2)	216.00	648.00
2.11133	Troop Officer Bunkroom (4)	65.00	195.00
2.11211	Commanding Officer Bath	4.10	12.30
2.11212	Executive Officer Bath	3.20	9.60
2.11212	Officer Semi-Private Bath (Dept Head)	1.25	3.75
2.11213	Officer Semi-Private Bath	1.88	5.63
2.112202	Marine Officer Semi-Private Bath	28.13	84.38
2.1123	Troop XO Bath	3.10	9.30
2.11231	Troop CO Bath	3.70	11.10
2.121101	CPO Bunkroom (6)	36.00	108.00
2.121301	SNCO Bunkroom (6)	70.40	211.20
2.1221	CPO WC & SH	5.00	15.00
2.1223	SNCO WC & SH	9.17	27.50
2.13	Library	11.38	34.14
2.131101	Crew Living Space	48.00	144.00
2.131301	Troop Living Space	947.50	2,842.50
2.132101	Crew WR, WC, & SH	7.70	23.11
2.132301	Troop WR, WC, & SH	121.66	364.98
2.13301	Crew Recreation Room	56.16	168.47
2.14	VISITOR WASHROOM AND WATER CLOSET	0.72	2.15
2.14003	DECK WASHROOM AND WATER CLOSET	42.93	128.78
2.15301	Physical Fitness Room	17.43	52.28
2.15302	ATHLETIC GEAR STOREROOM	3.73	11.20
2.15402	CLOSED CIRCUIT TELEVISION CONTROL ROOM	15.72	47.15
2.16	CREW AND TROOP TRAINING ROOM	23.06	69.19

GROUP 2.2

2.21102	WARDROOM MESSROOM	27.96	83.89
2.21103	WARDROOM LOUNGE	9.54	28.63
2.21204	CHIEF PETTY, STAFF NONCOM. OFFICER LOUNGE	3.89	11.67
2.21205	CHIEF PETTY, STAFF NONCOM. OFFICER MESS	15.33	45.99
2.21305	CREW AND TROOP MESSROOM	33.04	99.13
2.22103	BAKERY	5.18	15.53
2.22107	THAW ROOM	1.36	4.07
22.2403	CREW AND TROOP SCULLERY	3.84	11.51
2.22201	CO GALLEY	5.70	17.11
2.22202	WARDROOM GALLEY	5.99	17.98
2.22204	GALLEY	26.81	80.44

2.22401	WARDROOM SCULLERY	2.44	7.32
2.23	SUPPLY DEPARTMENT STOREROOM (DRY PROVISION)	30.54	91.63
2.23401	PROVISIONS ISSUE ROOM	2.06	6.18
GROUP 2.3			
2.36003	TRIAGE	20.00	60.00
GROUP 2.4			
2.41005	VENDING MACHINE AREA	1.84	5.53
2.42001	LAUNDRY	27.15	81.44
GROUP 2.5			
2.51001	OFFICER BAGGAGE STOREROOM	0.42	1.25
2.51002	CHIEF PETTY OFFICER BAGGAGE STOREROOM	0.56	1.67
2.51003	CREW BAGGAGE STOREROOM	0.56	1.67
2.52003	COMMANDING OFFICER STOREROOM	2.00	6.00
2.55001	FOUL WEATHER GEAR LOCKER	1.70	5.09
2.55002	DRYING ROOM	2.29	6.87
GROUP 2.6		0.00	0.00
GROUP 2.7			
2.71001	LIFE JACKET LOCKER	2.68	8.04
GROUP 3.1			
3.11	STEERING GEAR PUMP ROOM	28.40	85.21
3.11003	STEERING GEAR RAM ROOM	35.42	106.26
GROUP 3.2			
3.2	DAMAGE CONTROL PETTY OFFICER WORK CENTER	14.40	43.20
3.2	WELL DECK, STA/BLST CONT RM AND CONFLAGARATION	21.50	64.50
3.21	DAMAGE CONTROL UNIT PATROL STATION	8.40	25.19
3.21002	SECONDARY DAMAGE CONTROL CENTRAL	18.40	55.20
3.22	DAMAGE CONTROL AQUEOUS FILM FORMING FOAM	4.14	13.32
3.22	DAMAGE CONTROL DESMOKING EQUIPMENT	11.86	30.87
3.22	DAMAGE CONTROL DEWATERING EQUIPMENT	12.61	34.25
3.22	DAMAGE CONTROL EQUIPMENT STOREROOM	8.19	20.43
3.22	DAMAGE CONTROL FIREFIGHTER DRESSOUT	8.27	23.93
3.22	DAMAGE CONTROL HAZARDOUS MATERIAL SPILL KIT	1.63	3.59
3.22	DAMAGE CONTROL P-100 AND ACCESSORIES	3.59	9.23
3.22	DAMAGE CONTROL PERSONAL PROTECTION	3.41	11.24

	EQUIPMENT		
3.22	DAMAGE CONTROL REPAIR STATION	51.67	155.01
3.22	DAMAGE CONTROL RESCUE ASSISTANCE AND REENTRY	3.55	10.65
3.22	DAMAGE CONTROL SHORING	10.90	24.90
3.22019	HELICOPTER CRASH RESCUE LOCKER	0.00	0.00
3.25	AFFF RESERVE AND TRANSFER STATION	3.55	10.65
3.25	HEPTAFLUOROPROPANE CYLINDER ROOM	5.14	15.41
3.25101	AQUEOUS FILM FORMING FOAM STATION	40.18	120.55
3.25201	CONFLAGRATION STATION	7.31	21.93
GROUP 3.3			
3.3	SUPPLY DEP OFFICE (HAZARD MATERIAL MIN. CENTER)	6.73	20.18
3.30202	EXECUTIVE DEPARTMENT OFFICE (ADMINISTRATION)	2.69	8.06
3.30203	EXECUTIVE DEPARTMENT OFFICE (PERSONNEL)	3.23	9.68
3.30209	MAINTENANCE AND MATERIAL MANAGEMENT OFFICE (3M)	4.34	13.01
3.30224	COMMAND MASTER CHIEF OFFICE	0.90	2.70
3.30301	ENGINEERING DEPARTMENT OFFICE	18.06	54.17
3.30402	SUPPLY DEPARTMENT OFFICE (DISBURSING)	14.81	44.44
3.30404	SUPPLY SUPPORT CENTER	18.14	54.42
3.30406	SUPPLY DEPARTMENT OFFICE (FOOD SERVICE)	5.46	16.37
3.30407	SUPPLY DEPARTMENT OFFICE (SHIP STORE)	5.66	16.99
3.30411	SUPPLY DEPARTMENT OFFICE (ADMINISTRATION)	1.88	5.65
3.30501	DECK DEPARTMENT OFFICE	14.56	43.68
3.30503	OFFICER OF THE DECK STATION NO 1	1.40	4.20
3.30503	OFFICER OF THE DECK STATION NO 2	1.60	4.80
3.30601	OPERATIONS DEPARTMENT OFFICE	23.00	69.00
3.30609	DOCUMENT DESTRUCTION ROOM	0.57	1.71
GROUP 3.5			
3.5	MOORING STATION	174.25	356.40
3.5	REPLENISHMENT AT SEA STATION	6.60	18.60
3.5	RIGID INFLATABLE BOAT STOWAGE	63.49	190.46
3.51001	WINDLASS MACHINERY ROOM	33.90	101.70
3.51002	CHAIN LOCKER	32.22	96.65
3.51003	CHAIN LOCKER SUMP	4.25	12.75
3.53007	FUELING AT SEA STATION	18.59	105.50
GROUP 3.6			
3.6	CARPENTER SHOP AND DAMAGE CONTROL SHOP	17.38	52.13
3.61101	FILTER CLEANING SHOP	25.00	75.00
3.61201	ELECTRICAL SHOP	46.40	139.20
3.61202	STORAGE BATTERY SHOP	6.24	18.72

3.61205	ELECTRICAL SERVICE SHOP	14.65	43.95
3.61207	TOOL ISSUE ROOM	11.90	35.70
3.61403	OIL AND WATER TEST LABORATORY	6.20	18.59
3.64	BOAT GEAR REPAIR STATION	17.30	51.90
3.64	HULL REPAIR SHOP	36.78	110.33

GROUP 3.7

3.7	HAZARDOUS MATERIAL EQUIPMENT ROOM AND STOREROOM	11.86	35.58
3.7	SUPPLY DEPT (HAZARD MATERIAL MIN. CENTER)	9.74	29.21
3.71	BEVERAGE CYLINDER LOCKER	0.78	2.34
3.71	LCAC REPAIR PARTS STOREROOM	75.80	227.40
3.71	LCAC REPAIR WORK CENTER AND STOREROOM	5.41	16.22
3.71	SUPPLY DEP. ISSUE ROOM	68.41	205.23
3.71	SUPPLY DEP. STOREROOM (BULK CONSUMABLES)	35.38	106.13
3.71	SUPPLY DEP. STOREROOM (BULK REPAIR PARTS)	14.03	42.09
3.71	SUPPLY DEP. STOREROOM (CANNED SODA)	16.01	48.02
3.71	SUPPLY DEP. STOREROOM (CHILL)	30.33	90.98
3.71	SUPPLY DEP. STOREROOM (COST OF OPS.)	4.19	12.56
3.71	SUPPLY DEP. STOREROOM (FLAMMABLE GAS CYLINDERS)	31.78	95.33
3.71	SUPPLY DEP. STOREROOM (FREEZE)	44.53	133.58
3.71	SUPPLY DEP. STOREROOM (GALLEY CONSUMABLES)	15.31	45.92
3.71	SUPPLY DEP. STOREROOM (LAUNDRY)	2.95	8.86
3.71	SUPPLY DEP. STOREROOM (NON-FLAMABLE GAS CYL.)	7.83	23.50
3.711101	SUPPLY DEP. STOREROOM (FLAMMABLE LIQUIDS)	16.64	49.92
3.711205	SUPPLY DEP. STOREROOM (INERT GAS CYLINDER)	9.25	27.75
3.71201	SUPPLY DEP. STOREROOM (SPECIAL CLOTHING)	15.35	46.05
3.713101	SUPPLY DEP. STOREROOM	16.42	49.25
3.71321	SUPPLY DEP. STOREROOM (REPAIR PARTS)	25.27	75.81
3.71507	PACKAGE CONVEYOR	10.50	28.80
3.72	GAS FREE ENGINEERING EQUIPMENT ROOM	18.72	56.16
3.72001	ENGINEER STOREROOM	7.08	21.24
3.72003	PORTABLE ELECTRICAL TOOLS ISSUE ROOM	15.40	46.20
3.73002	NAVIGATION STOREROOM	5.30	15.90
3.74	PAINT ISSUE ROOM	13.95	41.85
3.74	STRONG ROOM	10.30	30.90
3.74001	DECK GEAR LOCKER	16.24	48.72
3.74004	BOATSWAIN STOREROOM	48.95	146.84
3.78	FACILITIES MAINTENANCE LOCKER	3.72	11.15
3.78	WATER HEATER ROOM	13.63	40.89
3.78001	CLEANING GEAR LOCKER	14.70	44.11

GROUP 3.8

3.8	CARGO HANDLING AREA	38.10	91.70
3.8	VEHICLE DECK RAMP		405.00
3.81	ACCOMMODATION LADDER ROOM	32.10	96.30
3.82101	PASSAGE	1,525.99	4,577.97
3.82103	ACCESS TRUNK	19.38	58.14
3.82105	VESTIBULE	2.72	8.15
3.82201	ESCAPE TRUNK	46.32	138.97
GROUP 3.9			
3.9	MOTOR GAS TANK	-	9.88
3.9	PLUMBING WASTE WATER TANK	10.34	32.42
3.9	VERTICAL LAUNCH SYSTEM FOUNDATION	0.00	52.80
3.9	WASTE OIL TANK	30.00	36.00
3.91	DIESEL GENERATOR LUBRICATING OIL STORAGE TANK	1.44	4.80
3.91101	FUEL TANK	-	1,700.00
3.9111	FUEL OVERFLOW TANK	-	26.48
3.91301	LUBRICATING OIL STORAGE TANK	-	51.40
3.92002	BALLAST TANK	-	7,245.43
3.93001	POTABLE WATER TANK	-	99.07
3.94	OILY WASTE CONCENTRATE TANK	-	9.56
3.94	VACUUM COLLECTING, HOLDING AND TRANSFER ROOM		151.40
3.94103	VACUUM COLLECTING, HOLDING AND TRANSFER TANK	-	27.79
3.94201	OILY WASTE HOLDING TANK	-	15.93
3.95	FLOODABLE VOID	-	71.69
3.95001	VOID	-	313.07
3.96001	COFFERDAM	-	14.79
GROUP 4.1			
4.11402	CENTRAL CONTROL STATION	31.33	93.98
4.12401	ENCLOSED OPERATING STATION	47.35	142.06
4.13	INTAKE FILTER ROOM	51.29	153.88
4.13301	UPTAKE ENCLOSURE	5.51	14.33
4.13301	UPTAKE SPACE	59.81	161.57
4.14201	INTAKE TRUNK	13.37	36.84
4.14301	UPTAKE SPACE	17.54	45.61
4.15301	UPTAKE SPACE	300.66	836.95
4.16	STACK	31.16	120.13
4.16301	UPTAKE SPACE	7.02	17.88
GROUP 4.2			
4.2	SHAFT ALLEY		0.00
GROUP 4.3			

4.3	LOAD CENTER ROOM	69.21	207.64
4.3	MAIN MACHINERY ROOM	537.87	1,776.86
4.3	PLASTIC WASTE EQUIPMENT ROOM	6.89	20.68
4.3	PLASTIC WASTE STOREROOM	3.61	10.83
4.3	SOLID WASTE PROCESSING ROOM	10.42	31.27
4.31001	AUXILIARY MACHINERY ROOM	641.13	2,196.57
4.32001	AIR CONDITIONING MACHINERY ROOM	56.60	174.81
4.33	LITHIUM BATTERY STOWAGE (NEW BATTERIES ONLY)	13.00	31.80
4.331402	ELECTRIC POWER CONVERSION ROOM	18.38	55.14
4.35	MOTOR GAS SERVICE STATION	72.93	218.78
4.35	WATER MIST FIRE EXTINGUISHING PUMP ROOM	16.88	50.63
4.35	WATER MIST FIRE EXTINGUSHING STORAGE TANK	4.68	14.03
4.35001	DEBALLAST AIR COMPRESSOR ROOM	48.35	136.03
4.36104	VENT	-	277.40
4.36201	FAN ROOM	149.37	448.11
4.36203	VENTILATION TRUNK	-	35.05

GROUP 5.1

5.1	UNASSIGNED		2,727.98

Annex G – Stability Calculations

Hydrostatics

Hydrostatics			
GM=KB+BM-KG			
KB=(5/6-C_B/(3C_W))T			
BM=(LB^3/(12*displacement))Cit			
GMt (m)	2.06	GMl (m)	591.66
KB_MH (m)	4.18	KB_OA (m)	4.20
KB_SH (m)	6.10	I_MH	6,536,581
KB_OA (m)	4.20	I_SH	33,345.64
I_MH	26,211.05	I_tot	6,603,272
I_SH	68.22	BMl	596.53
y-bar	13.5	Cit_MH	0.52
I_tot	74,698.99	Cit_SH	0.46
BMt (m)	6.75		
Cit_MH	0.52		
Cit_SH	0.46		
MTc		304.48	
TPc		22.52	
Trim Calculations		**Ballast Down Calculations**	
Moment to trim 1 cm	304.48	TPc	22.52
Trim Needed(m)	9.09	Ballast Needed (m)	1.5
Moment Arm (m)	71.75		
Total Weight (mt)	3,856.44	Total Weight (mt)	3377.3
$\cancel{V}_{trim}$ (m^3)	3,762.38	$\cancel{V}_{ballast}$ (m^3)	3,294.93
Safety Margin (%)	5	Safety Margin (%)	0
$\cancel{V}_{trim}$ Margin (m^3)	188.12	$\cancel{V}_{ballast}$ Margin (m^3)	0
$\cancel{V}_{trim}$ Total (m^3)	3,950.5	$\cancel{V}_{ballast}$ Total (m^3)	3,294.93
Total $\cancel{V}$ (m^3)		7,245.4	
Total Ballast Weight (mt)		7,426.565	

Stability while Ballasting

Stage	0	1.5m	1º	2º	3º	4º	5º
Inputs							
T mh (m)	7	8.5	8.5	8.75	8.75	6.75	9
T sh (m)	2	3.5	3.5	3.75	3.75	3.75	4
~~V~~ underwater_mh (m^3)	8,686	12,041	12,541	13,252	14,485	14,413	14,342
~~V~~ underwater_sh (m^3)	92	271	283	297	314	332	220
AW mh (m^2)	2,087	2,367	2,396	2,432	2,500	2,637	2,861
AW sh (m^2)	91	142	142	142	140	138	137
KG (m)	9	7	6.9	6.85	6.8	6.7	6.7
Results							
KB (m)	4.2	5.2	5.2	5.3	5.3	5.3	5.4
GMt (m)	1.9	4.3	4.2	4.1	3.6	3.6	3.8
BMt (m)	6.6	6.1	5.9	5.6	5.1	5.1	5.1

Crane Stability

From the GZ curve a prediction of the heel of the RSTS when it lifts a M1A1 tank at a boom of 30 m . The GZ curve was corrected by subtracting GG' created from lifting a M1A1 tank. The GZ curve first crosses the x-axis at 10 degrees. When the RSTS lifts a M1A1 tank the ship heels 10 degrees starboard. In order to keep the ship stable the port side hull can be filled with ballast to counteract the weight of the lifted tank.

$$GZ_{corrected} = GZ - GG' = GZ - (w*d*\cos(\theta))/\Delta) = GZ - (75mt*45m*\cos(\theta))/11{,}374mt)$$
$$= GZ - 0.296*\cos(\theta)$$

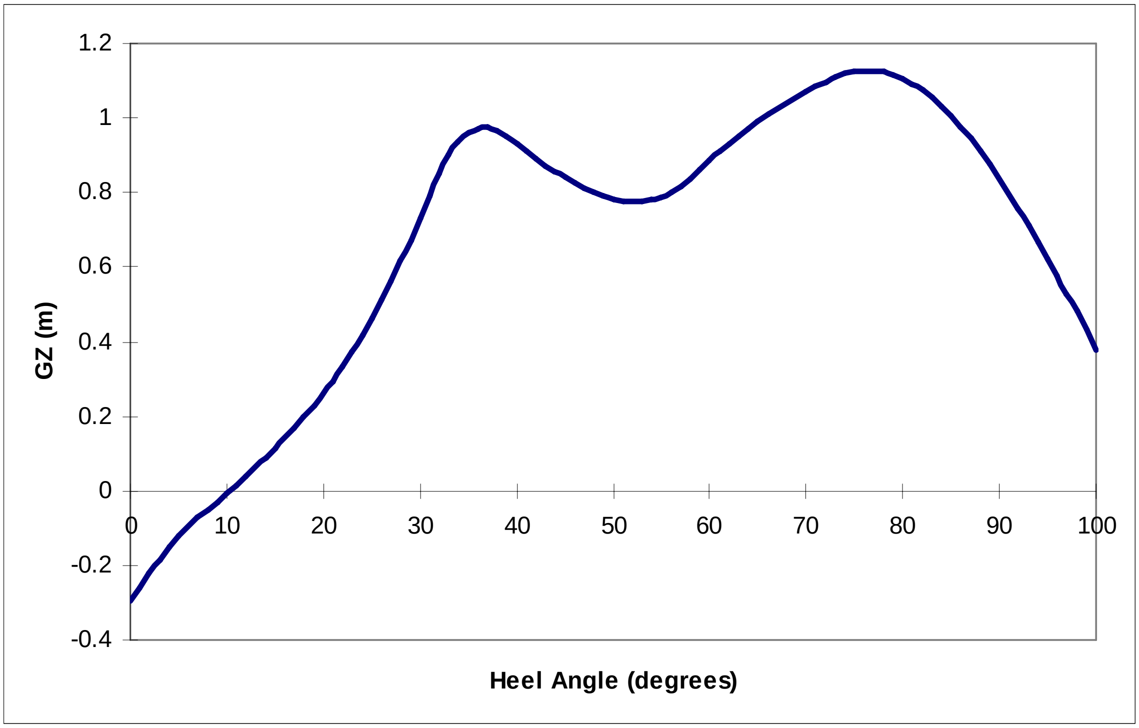
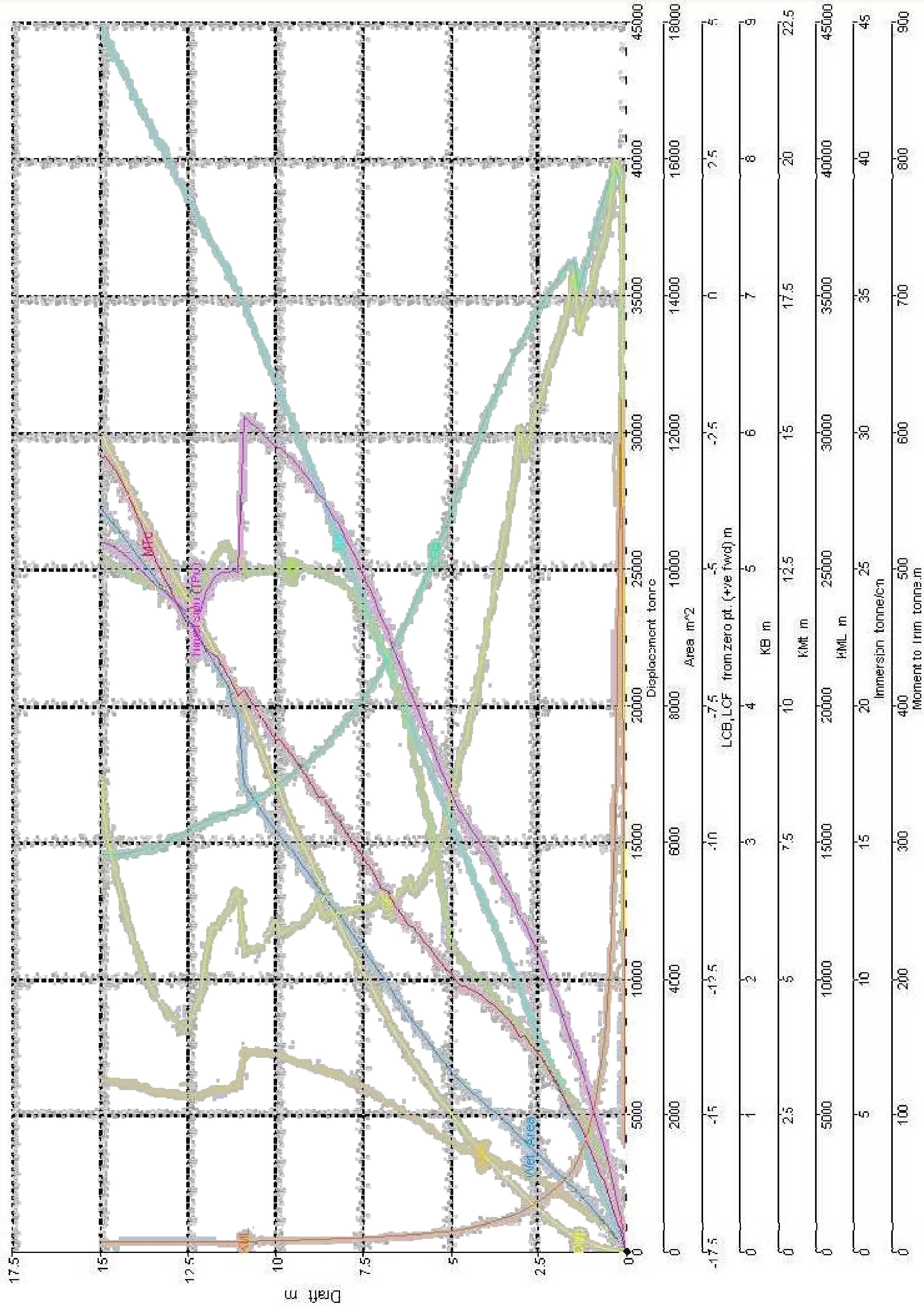


Figure 22: Crane Stability GZ Curve

Curves of Form



Annex H - Diesel Generator Set Data

WÄRTSILÄ **Generating sets**

WÄRTSILÄ GENSET 38

Main data

Cylinder bore.................................380 mm
Piston stroke.................................475 mm
Cylinder output.......................... 725 kW/cyl
Engine speed.................................600 rpm
Mean effective pressure.................26.9 bar
Piston speed...................................9.5 m/s
Generator voltage..................... 0.4–13.8 kV
Generator efficiency.................... 0.96–0.98

Fuel oil specification:
730 cSt/50°C
7200 sR1/100°F
ISO 8217, category ISO-F-RMK 700
SFOC 175–179 g/kWh at ISO condition

Option:
Common rail fuel injection.

Rated power

Engine type	50 Hz, 60 Hz	
	Eng. kW	Gen. kW
6L38	4 350	4 200
8L38	5 800	5 600
9L38	6 525	6 300
12V38	8 700	8 400
16V38	11 600	11 200

Generator output based on a generator efficiency of 96.5%.

Dimensions (mm) and weights (tonnes)

Engine type	A*	E*	I*	K	L*	Weight*
6L38	9 600	2 900	1 655	3 135	4 485	90
8L38	12 000	2 900	1 705	3 135	4 475	110
9L38	12 300	3 100	1 805	3 135	4 575	130
12V38	11 900	3 600	2 015	2 855	4 945	160
16V38	13 300	3 800	2 015	2 855	5 120	200

* Dependent on generator type and size.
For definitions see page 87.